Antenna arrangement for radio communication terminals

Antenna for a radio communication terminal, having a first antenna element comprising a main radiator (1) for the terminal, and a second antenna element comprising a counterpoise (2), wherein said counterpoise defines walls (3) of a screened compartment (6) carrying a functional component (7), such as a camera, of the terminal therein. A screened cable (8) runs from the interior of said compartment through said walls to a cooperating member (9) of said functional component outside said compartment, wherein a screening member (10) of said cable connects the main radiator to the counterpoise. A feeding point (11) of the counterpoise is connected to a tuning filter (12).
Description

Field of the invention

[0001] The present invention relates generally to antenna arrangements for radio communication terminals, such as mobile phones. In particular, the invention relates to antennas arrangements suitably devised to occupy minimal space in a radio communication terminal.

Background

[0002] The first commercially attractive cellular telephones or terminals were introduced in the market at the end of the 1980's. Since then, the mobile phone industry has had an enormous development both regarding quality of service and transmission capabilities, as well as the technology for producing advanced communications terminals. A lot of effort has been made in making smaller terminals, with much help from the miniaturisation of electronic components and the development of more efficient batteries. In only a couple of decades the communication systems have gone from analogue to digital, and at the same time the dimensions of the communication terminals have gone from briefcase size to the pocket size phones of today. Today, numerous manufacturers offer pocket-sized terminals with a wide variety of capabilities and services, such as packet-oriented transmission and multiple radio band coverage. Still today, mobile phones are getting smaller and smaller and the size is generally considered to be an important factor for the end customer. The development in electronics has made it possible to miniaturise the components of the terminals, at the same time making the terminals capable of performing more advanced functions and services. The development of new transmission schemes, the so-called 3rd generation mobile system standing at the door and the 4th generation to be expected maybe ten years later, also provides the possibility to convey more advanced data to the wireless communication terminals, such as real time video.

[0003] The end users have a number of conflicting requirements on the mobile phones. Basically, the terminal should be as small and light-weight as possible. Furthermore, is should provide more and more advanced functions, have a long battery time, and a user-friendly interface. As technology advances, new or previously implemented features can be miniaturised, rendering smaller terminals. This concerns e.g. battery technology and electronics. Still, there is only so much space in a terminal, and in order to be competitive the elements of the terminal must be carefully packaged. Built-in antennas of different types have eliminated the need for protruding antenna elements. However, a so called PIFA (Planar Inverted-F Antenna) will instead add to the height of the terminal, since it must be placed a certain distance from the PCB ground plane in order to provide a sufficient bandwidth.

Summary of the invention

[0004] A main target for terminal providers today is consequently to produce highly compact mobile phones, with a balanced relation between size and performance. Furthermore, regardless of how advanced future accessible mobile services will be, there will most likely always be a big market for terminals including at least basic calling capabilities, where small size is the number one priority. If only the user interface can be provided in a suitable manner, a pen-sized terminal would probably be a huge success even if it did not provide auxiliary features like transmission and presentation of video. It is therefore a general object of the invention to provide means for miniaturisation of mobile phone terminals.

[0005] According to a first aspect, this object is fulfilled by an antenna for a radio communication terminal, having a first antenna element comprising a main radiator for the terminal, and a second antenna element comprising a counterpoise, and wherein said counterpoise defines walls of a screened compartment carrying a functional component of the terminal therein.

[0006] In one embodiment, a screened cable runs from the interior of said compartment through said walls to a cooperating member of said functional component outside said compartment, wherein a screening member of said cable connects the main radiator to the counterpoise.

[0007] Preferably, a feeding point of the counterpoise is connected to a tuning filter.

[0008] In a preferred embodiment, said counterpoise is arranged adjacent to a first side edge of said main radiator, wherein said screening member connection to the counterpoise is located near a first end of said first side edge, and said feeding point is located near a second end of said first side edge.

[0009] Preferably, said main radiator is substantially arranged in a plane, and said counterpoise is arranged in the extension of said plane adjacent to said first side edge.

[0010] In one embodiment, said screened cable is a multiple conductor flat cable and said screening member comprises a screening enclosure of the cable. Alternatively, said screened cable is a multiple conductor flat cable and said screening member comprises a first and a second screening foil located on opposite sides of said flat cable.

[0011] Preferably, said tuning filter is a multiband tuning filter.

[0012] In one embodiment, said main radiator is a main PCB of the terminal. Alternatively, said main radiator is a chassis for the terminal.

[0013] In one embodiment, said functional component is a camera, wherein an aperture is formed in said walls of the counterpoise for allowing optical access to said camera.

[0014] Preferably, a first and a second aperture are
formed in said walls of the counterpoise, facing different directions, wherein means are provided for turning said camera inside said counterpoise compartment, for allowing optical access through either said first or said second aperture.

[0015] In one embodiment, said first aperture faces a front side of said terminal, and said second aperture faces a rear side of said terminal. Alternatively, said first aperture faces a front side of said terminal, and said second aperture faces an upward direction in the longitudinal extension of the terminal.

[0016] In another embodiment, said first aperture faces a front side of said terminal, said second aperture faces an upward direction in the longitudinal extension of the terminal, and a third aperture faces a rear side of said terminal, wherein means are provided for turning said camera inside said counterpoise compartment, for allowing optical access through either said first, said second, or said third aperture.

[0017] Preferably, means for turning said camera comprises a support mechanism with a rotation bearing for said camera, and a turning knob connected to the camera, accessible from the outside of a housing for the terminal.

[0018] In one embodiment, said compartment defined by the counterpoise has a cylindrical shape extending parallel to said first side edge. Said cylindrical compartment may have a circular cross-section. In another embodiment, said cylindrical compartment has a rectangular cross-section. Other cross-section shapes are also possible, and may be partly determined by the shape of the functional component placed therein.

[0019] Advantageously, said cylindrical compartment is defined by an envelope wall with open ends. Alternatively, said cylindrical compartment is defined by an envelope wall and end walls.

[0020] In one embodiment, said functional component is a speaker. In such an embodiment, or in an embodiment carrying a camera in the counterpoise, said counterpoise is preferably placed at an upper end of the terminal.

[0021] In another embodiment, said functional component is a battery for providing electrical energy to the terminal.

[0022] Preferably, said compartment defined by the counterpoise has a cylindrical shape extending parallel to said first side edge, and having an inner cross-section corresponding in shape and dimension with the exterior of said battery, for proper fitting of the battery in said compartment.

[0023] Suitably, said battery is extractable from said compartment, and preferably said battery is extractable from an end of said cylindrical compartment.

[0024] In such an embodiment, said counterpoise is preferably placed at a lower end of the terminal.

[0025] The detailed description shows specific features of various embodiments related to the aspects above. 

[0026] The features and advantages of the present invention will be more apparent from the following description of the preferred embodiments with reference to the accompanying drawings, on which

Fig. 1 schematically illustrates an antenna arrangement, in accordance with a general embodiment of the invention;

Fig. 2 schematically illustrates the antenna arrangement according to the invention, in a combined antenna and camera embodiment;

Fig. 3 shows a terminal including the features of Fig. 2, in a sectional side view;

Fig. 4 schematically illustrates the antenna arrangement according to the invention, in a combined antenna and battery embodiment;

Fig. 5 shows a terminal including the features of Fig. 4, in a sectional side view;

Fig. 6 schematically illustrates an elevated view of another embodiment of the antenna arrangement according to the invention;

Fig. 7 shows an unassembled antenna arrangement according to Fig. 6, in a sectional side view;

Fig. 8 shows the assembled antenna arrangement according to Fig. 6, in a sectional side view; and

Fig. 9 illustrates a SWR measurement for a test model devised according to the invention.

[0027] The present description relates to the field of radio communication terminals. The term radio terminal or communication terminal, also denoted terminal in short in this disclosure, includes all mobile equipment devised for radio communication with a radio station, which radio station also may be mobile terminal or e.g. a stationary base station. Consequently, the term radio terminal includes mobile telephones, pagers, communicators, electronic organisers, smartphones, PDA:s (Personal Digital Assistants) and DECT terminals (Digital Enhanced Cordless Telephony). Hence, although the structure and characteristics of the antenna design according to the invention is mainly described herein, by way of example, in the implementation in a mobile phone, this is not to be interpreted as excluding the implementation of the inventive antenna design in other types of radio terminals, such as those listed above. Furthermore, it should be emphasised that the term comprising or comprises, when used in this description and in the appended claims to indicate included features, elements or steps, is in no way to be interpreted as excluding the presence of other features elements or steps than those expressly stated.

[0028] Exemplary embodiments will now be described with references made to the accompanying drawings.
According to the invention, a terminal antenna comprises a main radiator element. The main radiator is formed by the chassis or conducting parts of the main chassis/PCB or casing of the terminal. A counterpoise type feeding system is used to get a sufficiently wide band antenna system. A screening compartment devised to house a functional component of the terminal is used as counterpoise. Or, to put it in other words, the counterpoise defines walls of a screened compartment carrying a functional component of the terminal therein.

Fig 1 illustrates a general embodiment of the present invention. The drawing illustrates a portion of the conducting parts of the main chassis or PCB 1, which preferably extends in the longitudinal direction of the terminal. The counterpoise 2 to the main radiator 1 defines a hollow compartment 6 within its walls 3. Dependent on how necessary it is to shield the functional component 7, located within the compartment 6, end walls 4, 5 may be closed or open. Counterpoise 2 extends essentially perpendicular to the main radiator 1 adjacent to a first side edge 13 of the main radiator 1. Counterpoise 2 is fed at a feeding point 11 connected to a tuning filter 12. According to a preferred embodiment of the invention, this tuning filter 11 is firmly tuned to two or more pass bands, rendering the entire antenna multiband performance. This differs from the prior art solutions in which the tuned antenna generally provides one pass band. A radiator connection 10 electrically connects the main radiator 1 to counterpoise 2. In order to provide sufficient impedance to feeding point 11, the radiator connection 10 is located near a first end 14 of the first side edge, whereas the feeding point 11 is located near a second end 15 of the first side edge 13, opposite said first end 14.

The necessary wiring for driving or using the functional element 7 determines how many leads are needed to functional element 7. In order to make use of functional element 7, it must be connected to some form of co-operating member 9, preferably by an electrical connection 8. In the illustrated embodiment of fig 1, a multiple conductor flat cable 8 is provided between functional element 7 and the co-operating member 9. The multiple conductor flat cable 8 may comprise leads for both signal data and power. Had such a cable been used in an antenna arrangement wherein the counterpoise 2 was electrically separated from the main chassis 1, problems with screening and antenna function would occur unless the cable was properly de-coupled for radio frequency. This problem is solved here by providing the cable 8 with a screening enclosure or screening foils on both sides, constituting radiator connector 10. This provides a simple and low cost way of connecting the functional element 7 with a screened cable or conductor. Despite the rather wide flat band cable 8, sufficient band width is obtained by the illustrated arrangement, locating cable screen 10 near one corner 14 and feeding point 11 near the opposite corner 15. A spacing of 30-50 mm, preferably at least 40 mm, between the cable screen 10 and the feeding point 11, will provide sufficient impedance for obtaining multiband performance.

Fig 2 illustrates an embodiment of the invention implementing a camera 20 within the counterpoise compartment. The camera 20 may be a snapshot camera and/or a video camera. Leads in cable 8 conduct data signals, control signals, and electrical power between camera 20 and the co-operating camera control device 9. The camera control device 9 preferably makes use of or comprises a microcontroller system. Image data storage means are preferably also placed outside the counterpoise compartment, in or connected to said camera control device. The specific realisation of camera 20 is not important for the present invention, but as the skilled person would realise camera 20 includes at least a light sensitive focal plane, a shutter and a lens 26. In order to provide optical access to camera 20, at least one aperture 21 is formed in the envelope wall of counterpoise 2. Needless to say, if the arrangement according to fig 2 is arranged within a terminal housing, a corresponding aperture must be arranged in said housing.

In accordance with the specific embodiment illustrated in fig 2, the envelope wall of counterpoise 2 is provided with at least two apertures 21, 22, wherein camera 20 is rotatable in the counterpoise compartment 6 to align its lens 26 with either one of said apertures 21, 22. A first aperture 21 is preferably arranged to face a front side of a terminal housing. As such, camera 20 is devised to make us of aperture 21 for capturing images of objects facing the front side of such a terminal, for instance a terminal user. When using a digital camera 20, implemented in a communication terminal, a terminal display is preferably used as a finder, on which the present field of view as seen by camera 20 is shown to the user. If the user wants to capture an image of a certain object other than the user him-/herself, the user must have visual access to the terminal display at the same time as the camera is pointed in another direction. For this reason, camera 20 may be turned about 180°, hence facing the rear side of the terminal, through an aperture 23 (not shown). This way, a user may hold up a terminal in front of him facing the rear side of the terminal towards the object to be photographed, at the same time monitoring the expected image on the display. However, since the display does not function as a normal finder of a traditional camera, and must be held at a certain distance of the eye, it may be difficult to obtain a good visual image from the display dependent on the lightening conditions. For this reason, one embodiment of the invention according to fig 2, further includes an upper aperture 22 to which the camera lens 26 is rotatable. This way, the terminal may be held in a substantially horizontal orientation when capturing an image, and it is thereby easier to monitor the object and the display without risking the terminal to obscure the object to be captured. Furthermore, it will be easier to shield the display by the use of a hand, rendering better
visual camera 20 is supported by some form of bearings 24 which makes it possible to freely rotate camera 20 within counterpoise 2. Means for rotating camera 20 may be provided by an electrical engine, but preferably a manual handle such as a turning knob 25 is simply connected to camera 20 and accessible from outside the terminal housing. If camera 20 is rotatable only within a limited range of degrees, the conductor cable 8 may be directly connected by soldering or the like to camera 20. Alternatively, a slip ring arrangement may be used to connect conductor cable 8 to camera 20.

Fig 3 illustrates quite schematically a radio communication terminal implementing the embodiment of fig 2. The main chassis or PCB 1 extends in the longitudinal direction of the terminal. The counterpoise 2 is connected to the main radiator 1 at the upper side edge of the main radiator 1, and is also evidenced by the drawings in fig 1 and fig 2. Counterpoise 2 houses a camera 20, which is rotatable to face and receive light from different directions. In this illustrated embodiment, images may be captured by reception of light from the front side 32, the rear side 33 and the upper side 34. The camera control device 9 is directed to the main chassis or PCB 1 and as illustrated in fig 2, further connected to camera 20. The terminal further includes functional electronics, user interface devices, and power supply means 30, have commonly denoted without further specification in the drawing. However, as the skilled person will realise, functional features 30 of the terminal may include display means, keyboard means, speaker and microphone means, control electronics and radio transceiver means, as well as a battery. A nonconductive housing 31 encloses the terminal.

With a traditional antenna arrangement, the camera or other conducting objects cannot be placed close to the antenna or counterpoise type feeding arrangement without affecting the antenna performance. However, by placing the camera in a screen compartment and using the screening as an antenna or counterpoise in accordance with the invention, the screening effect will prevent negative influence from the camera on the antenna.

Figs 4 and 5 illustrate another embodiment of the present invention in which the counterpoise compartment 6 is devised to contain a battery 40 for the terminal. Preferably the counterpoise 2 is placed at the lower end of the terminal, as indicated in the drawings. In this embodiment, battery 40 co-operates with a power supply and distribution unit 9, and is connected thereto by a power cable 8. As for the general embodiment of fig 1, the cable connection 8 is screened between the main radiator 1 and counterpoise 2. In the embodiment depicted in fig 4 only two leads are illustrated in cable 8, preferably devised to connect to opposite poles of battery 40. The battery cable 8 is connected to battery 40 at one end of the lower side edge of the main radiator 1, whereas tuning filter 12 connects to the feeding point of counterpoise 2 closer to the opposite second end of the lower side edge of the main radiator 1. A spacing of 30-50 mm, preferably at least 40 mm, between the cable screen 10 and the feeding point 11, will provide sufficient impedance for obtaining multiband performance.

Fig 5 corresponds to fig 3, but illustrates the embodiment of fig 4 as implemented in a terminal, such as a mobile phone. The main chassis or PCB 1 extends in the longitudinal direction of the terminal. Counterpoise 2, carrying battery 40 therein, is placed adjacent to lower side edge of the main radiator 1, and is connected thereto by the screening of a cable 8. As has been outlined in conjunction with fig 3, the terminal comprises further functional members 50, such as control units, radio transceiver devices, and user interfaces. A housing 51 encloses the chassis 1 and counterpoise 2, and preferably housing 51 is formed of a non-conducting material such as plastic.

In a particular embodiment of the antenna arrangement according to figs 4 and 5, the counterpoise is placed at the lower end of the terminal and has a cylindrical shape with a circular cross-section devised to contain a cylindrical AA cell type, or possibly a slightly thicker cell type. Preferably that cell type comprises a 3.6-Volt lithium battery suitable for use with a radio communication terminal. However, as the skilled person will realise, the shape of counterpoise 2 and battery 40 need not have a circular cross section, and the shape of counterpoise 2 may be devised to suit the shape of battery 40, or vice versa. The embodiments of figs 4 and 5 will render a thinner terminal, since no large flat battery adds to the thickness of the terminal.

The embodiment of figs 4 and 5 further adds design freedom to terminal development, since the top end of the terminal is free for other functions than the antenna.

Fig 6 illustrates an alternative realisation of the general embodiment of fig 1. Instead of employing a cylindrical counterpoise 2 with a compartment 6 defined by a circular cross section, the counterpoise compartment according to the embodiment of fig 6 has a rectangular cross section. Furthermore, counterpoise 2 is formed by a flat element 62 and a boxlike screening member 64, which is attached onto the flat element 62, thereby forming a counterpoise compartment. The embodiment of fig 6 corresponds in many ways to the embodiment of fig 1. A functional element 7, such as a camera, a speaker, or a battery is connected by cable 8 to a co-operating member 9. The antenna arrangement comprises a main radiator 61 including a conductive sheet of layer on the terminal PCB 60. The main radiator 61 may extend into the flat element 62 of the counterpoise, through a narrow neck portion 63. A boxlike member 64 is placed on top of flat member 62 and connected thereto, for instance by soldering. This way, a counterpoise is formed which encloses functional member 7 and acts as a screening therefor. Cable 8 is, as previously described, also screened. In a variant of this em-
1. The antenna as recited in claim 1, characterised in that a feeding point (11) of the counterpoise is connected to a tuning filter (12).

2. The antenna as recited in claim 2, characterised in that said counterpoise is arranged adjacent to a first side edge (13) of said main radiator, wherein said screening member connection to the counterpoise is located near a first end (14) of said first side edge, and said feeding point is located near a second end (15) of said first side edge.

3. The antenna as recited in claim 1, characterised in that a screened cable (8) runs from the interior of said compartment through said walls to a coop-

4. The antenna as recited in claim 2 and 3, characterised in that said counterpoise is arranged adjacent to said first side edge (13) of said main radiator, wherein said screening member connection to said counterpoise is located near a first end (14) of said first side edge, and said feeding point is located near a second end (15) of said first side edge.

5. The antenna as recited in any of the previous claims, characterised in that said main radiator is substantially arranged in a plane, and in that said counterpoise is arranged in the extension of said plane adjacent to said first side edge.

6. The antenna as recited in claim 2, characterised in that said screened cable is a multiple conductor flat cable and said screening member comprises a screening enclosure of the cable.

7. The antenna as recited in claim 2, characterised in that said screened cable is a multiple conductor flat cable and said screening member comprises a first and a second screening foil located on opposite sides of said flat cable.

8. The antenna as recited in claim 3, characterised in that said tuning filter is a multiband tuning filter.

9. The antenna as recited in any of the previous claims, characterised in that said main radiator is a main PCB of the terminal.

10. The antenna as recited in any of the previous claims, characterised in that said main radiator is a chassis for the terminal.

11. The antenna as recited in any of the previous claims, characterised in that said functional component is a camera (20), wherein an aperture (21,22,23) is formed in said walls of the counterpoise for allowing optical access to said camera.

12. The antenna as recited in claim 11, characterised in that a first (21) and a second (22,23) aperture are formed in said walls of the counterpoise, facing different directions, and in that means (24,25) are provided for turning said camera inside said counterpoise compartment, for allowing optical access through either said first or said second aperture.
13. The antenna as recited in claim 12, **characterised in that** said first aperture faces a front side of said terminal, and **in that** said second aperture (23) faces a rear side of said terminal.

14. The antenna as recited in claim 12, **characterised in that** said first aperture faces a front side of said terminal, and **in that** said second aperture (22) faces an upward direction in the longitudinal extension of the terminal.

15. The antenna as recited in claim 14, **characterised in that** a third aperture (23) faces a rear side of said terminal, wherein means are provided for turning said camera inside said counterpoise compartment, for allowing optical access through either said first, said second, or said third aperture.

16. The antenna as recited in any of the claims 12 to 15, **characterised in that** said means for turning said camera comprises a support mechanism (24) with a rotation bearing for said camera, and a turning knob (25) connected to the camera, accessible from the outside of a housing for the terminal.

17. The antenna as recited in claim 4, **characterised in that** said compartment defined by the counterpoise has a cylindrical shape extending parallel to said first side edge.

18. The antenna as recited in claim 17, **characterised in that** said cylindrical compartment has a circular cross-section.

19. The antenna as recited in claim 17, **characterised in that** said cylindrical compartment has a rectangular cross-section.

20. The antenna as recited in any of the claims 17 to 19, **characterised in that** said cylindrical compartment is defined by an envelope wall with open ends.

21. The antenna as recited in any of the claims 17 to 19, **characterised in that** said cylindrical compartment is defined by an envelope wall (3) and end walls (4,5).

22. The antenna as recited in any of the previous claims 1 to 10 or 17 to 21, **characterised in that** said functional component is a speaker.

23. The antenna as recited in any of the claims, **characterised in that** said counterpoise is placed at an upper end of the terminal.

24. The antenna as recited in any of the previous claims 1 to 10, **characterised in that** said functional component is a battery (40) for providing electrical energy to the terminal.

25. The antenna as recited in claim 4 and 24, **characterised in that** said compartment defined by the counterpoise has a cylindrical shape extending parallel to said first side edge, and having an inner cross-section corresponding in shape and dimension with the exterior of said battery, for proper fitting of the battery in said compartment.

26. The antenna as recited in any of the previous claims 24 or 25, **characterised in that** said battery is extractable from said compartment.

27. The antenna as recited in claim 26, **characterised in that** said battery is extractable from an end of said cylindrical compartment.

28. The antenna as recited in any of the previous claims 25 to 27, **characterised in that** said counterpoise is placed at a lower end of the terminal.
Fig. 1