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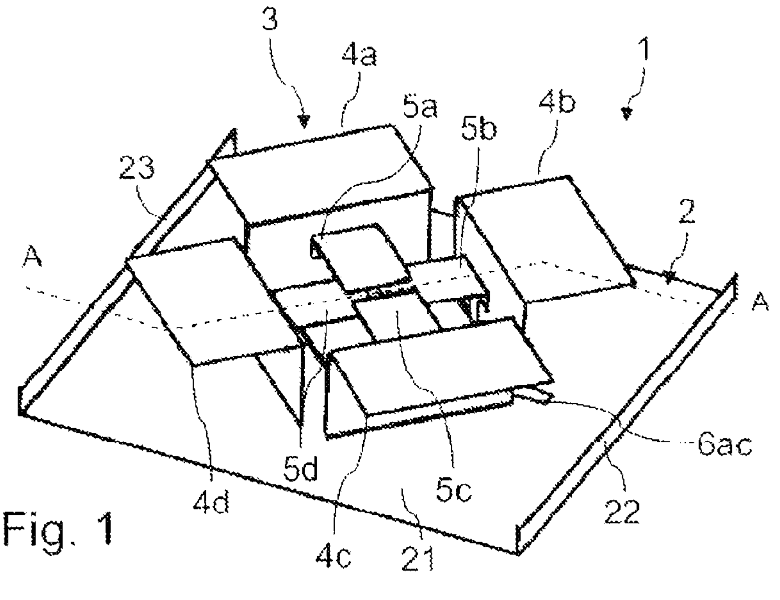

Fig. 1

(57) Abstract: The invention relates to a dual polarised radiating element (1) for a cellular base station antenna, comprising: -a reflector surface (21) for reflecting radiation energy, -four radiating monopoles (4a to 4d) distributed around an aperture area (8), each radiating monopole comprising a footing (42a to 42d) protruding from said reflector surface and a flange (41a to 41d) located above the reflector surface and protruding from said footing radially towards the outside, the flanges from adjacent monopoles extending radially perpendicular to each other, wherein it further comprises: -four element feeds (5a to 5d), each capacitively coupled to a respective monopole and protruding radially therefrom within the aperture area (8); -powering means (6ac, 6bd, 7a to 7d, 7ac, 7bd) connected to the element feeds.

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DUAL POLARISED RADIATING ELEMENT FOR CELLULAR BASE STATION ANTENNAS

The present invention relates to a dual polarised radiating element for a cellular base station antenna. Recently, the demand for antennas for mobile and wireless applications has increased dramatically. There are now a number of land based systems for wireless communications using a wide range of frequency bands.

Several cellular base station antenna manufacturers are proposing antennas having electrical dipoles located one quarter of a wavelength above a finite ground plane formed by a reflector. Dual polarisation is achieved by way of orthogonal linear polarisation obtained by excitation of the respective, mutually perpendicular electrical dipoles. These electrical dipoles are slanted 45° in opposite directions relative to the central longitudinal axis of the reflector.

Unfortunately, such antennas provide limited far field pattern performance: the horizontal 3dB HPBW (for Half Power Beam Width) stability faces large variation (for instance 65° +/-6°), the cross-polarisation level (for example the cross-polar discrimination at +/- 60° about 5dB) is too high across passbands up to 25% (for example 806-960MHz or 1700-2200MHz).

Document US2006/0109193 discloses an antenna improving the 3dB HPBW stabilisation. Moreover, this antenna also reduces the cross-polarisation level. This antenna comprises an array of dual polarized radiating elements mounted on a reflector structure for reflecting polarised radiofrequency signals. The reflector structure has a pyramidal or conical horn-like shape for each radiating element.

This antenna design significantly increases the manufacturing costs, since horn-like shapes require the design of specific moulds.

In order to reduce the cross-polarisation level, other designs include lateral elongated choke reflectors fixed on both sides of a reflector. These designs lead to complex and costly manufacturing processes.

There is thus a need for a simple antenna structure that provides good far field performance. It is therefore an object of the present invention to provide a dual polarised radiating element for a cellular base station antenna, comprising:

-a reflector surface for reflecting radiation energy,

-four radiating monopoles distributed around an aperture area, each radiating monopole comprising a footing protruding from said reflector surface and a flange located above the reflector surface and protruding from said footing radially towards the outside, the flanges from adjacent monopoles extending radially perpendicular to each other, wherein it further comprises:

-four element feeds, each capacitively coupled to a respective monopole and protruding radially therefrom within the aperture area ;

-powering means connected to the element feeds.

The four element feeds comprise each a footing portion and a flange portion connected to the upper part of the respective footing portion and perpendicular thereto, wherein each footing portion is capacitively coupled to a respective monopole at the level of its footing, and each flange portion is protruding radially from respective radiating monopole within the aperture area.

According to another embodiment, a pair of opposite element feeds extends above the reflector surface between two opposite footings.

According to another embodiment, each element feed comprises a first end portion capacitively coupled to a radiating monopole and a second end portion is protruding radially from said radiating monopole.

According to another embodiment, said first end portions of the element feeds are capacitively coupled to respective footings.

According to another embodiment, the first end portion of an element feed is approximately perpendicular to its second end portion.

According to another embodiment, said powering means comprises:

-a power divider ;

-a first connection line connecting the power divider to an element feed;

-a second connection line connecting the power divider to an opposite element feed and introducing a 180° phase relative to said first connection line.

According to another embodiment, said first and second connection lines have identical impedance amplitudes.

According to another embodiment, said flanges are comprised within a common plane surface.

According to another embodiment, said reflector surface is plane and said flanges are parallel to the reflector surface.

According to another embodiment, said flanges are tilted relative to said reflector surface.

According to another embodiment, each monopole further comprises at least one wing extending from a respective flange and being tilted relative to this flange.

According to another embodiment, said flanges have a rectangular shape.

According to another embodiment, said footings have a rectangular shape having the same length as said flanges.

According to another embodiment, said flanges are provided with through holes extending tangentially relative to said aperture area.

According to another embodiment, the radiating element further comprises sidewalls protruding from said reflector surface on the same side as the radiating monopoles, said radiating monopoles being located between said sidewalls.

According to another embodiment, the intersection between the reflector surface and the lateral sidewalls form parallel lines and wherein each pair of opposite element feeds extend according to a direction forming approximately 45° with said parallel lines.

According to another embodiment, one pair of element feeds partly covers the other pair of element feeds.

The advantage of the present invention will become apparent from the following description of several embodiments with reference to the accompanying drawings, in which:

- figure 1 is a perspective view of a radiating element according to a first embodiment of the invention;
- figure 2 is a section view of the radiating element of figure 1;
- figure 3 is a top view of the electrical connections made on a reflector of the radiating element of figure 1;
- figure 4 is a section view of a second embodiment of a radiating element according to the invention;
- figure 5 is a perspective view of an alternative monopole shape;
- figure 6 is a perspective view of another alternative monopole shape;
- figure 7 is a perspective view of still another alternative monopole shape.

Figures 1 and 2 illustrate a dual polarised radiating element 1 for a cellular base station antenna. The radiating element 1 comprises a reflector 2 for reflecting radiation energy. The reflector 2 of this embodiment comprises a plane portion 21 forming a reflector surface.

A radiating portion 3 comprises four radiating electrical monopoles 4a to 4d. The monopoles 4a to 4d are distributed around an aperture area (illustrated by circle 8 at figure 3). Each monopole 4 comprises a footing 42 and a flange 41 formed by respective wall portions. Each monopole 4a to 4d can be formed out of a bended metal sheet. Each flange 41a to 41d is located above the plane portion 21. Each flange 41 is protruding from a respective footing 42 in a radial direction towards the outside. The radial direction is defined starting from the centre of the aperture area 8. In order to generate the dual polarisation, two flanges 41 from adjacent monopoles 4 extend radially perpendicularly to each other.

The radiating portion 3 also comprises four element feeds 5a to 5d. Each element feed 5a to 5d is capacitively coupled to a respective monopole 4a to 4d. Each element feed 5a to 5d is protruding from its respective monopole within the aperture area. An electric field is generated in the aperture area 8, forming a magnetic source. The combination of a magnetic source and of the electrical monopoles improves the 3dB HPBW stability. The radiating portion 3 further comprises powering means connected to the feeds 5a to 5d and for which further details are provided below.

According to radiofrequency simulations and to measurements, a radiating element according to the invention provides at least the same far field pattern performance (say horizontal 3dB HPBW stability, cross-polar discrimination, front to back ratio) across passbands up to 25% (for example 806-960MHz or 1700-2200MHz) as known radiating elements. Simulations and measurements led on the embodiment illustrated at figures 1 and 2 provided the following results for the far field pattern:

- a 3dB HPBW stability of 65° +/-3 dB in passbands of 25%;
- 10 dB for cross-polar discrimination;
- 30 dB front to back ratio.

Moreover, these results were obtained with a radiating portion having a 54mm height, which guarantees a low profile and a limited weight.

A radiating element according to the invention further has a simple structure whose manufacturing cost is particularly low. Such a radiating element 1 can be used in antennas equipping mobile phone networks.

Each element feed 5a to 5d comprises a footing portion 52a to 52d and a flange portion 51a to 51d connected to the upper part of a respective footing portion. Each flange portion 51a to 51d is perpendicular to its respective footing portion 52a to 52d, the element feeds thus having a L-shape in cross section. Each flange portion 51a to 51d is thus protruding radially from a respective monopole 4a to 4d within the volume located under the aperture area 8. Flange portions 51a to 51d and corresponding flanges 41a to 41d are protruding in a same direction but on opposite sides. Each footing portion 52a to 52d is capacitively coupled to its respective radiating monopole 4a to 4d at the level of its footing 42a to 42d.

Each pair of element feeds 5a,5c or 5b,5d extends above the plane portion 21 between two opposite footings, respectively footings 42a, 42c and 42b, 42d. One pair of flange portions is located higher above the plane portion 21 than the other: flange portions 51a and 51c partly cover flange portions 51b and 51d. The opposite flange portions, say 51a,51c and 51b, 51d are separated by an air gap at the centre of the aperture area 8. Each element feed 5a to 5d can be formed out of a bended metal sheet.

In this embodiment, the flanges 41a to 41d have a rectangular shape. The footings 42a to 42d also have a rectangular shape. These flanges 41a to 41d have the same length as their respective footings 42a to 42d. The flanges 41a to 41d of this embodiment are parallel to the plane portion 21. These flanges 41a to 41d are comprised within a common plane surface. The footings 42a to 42d are perpendicular to the plane portion 21 and to their respective flanges 41a to 41d (the monopoles 4a to 4d thus having a L-shape in cross section).

In the embodiment illustrated at figures 1 to 3, the reflector 2 further comprises sidewalls 22 and 23. The sidewalls 22 and 23 may be formed simply by bending the plane surface 21. The monopoles 4a to 4d and the feeds 5a to 5d are located between these sidewalls 22 and 23. The sidewall 22 is parallel to the sidewall 23. The sidewalls 22 and 23 are perpendicular to the plane surface 21. The intersections between the sidewalls 22 and 23 and the plane surface 21 form parallel lines. Each pair of feeds 5 extending in a direction forming approximately a 45°angle with these parallel lines.

Figure 3 is a top view of electrical connections made on the plane surface 21. For each pair of feeds, powering means include a power divider, a first connection line between the power divider and the first feed, and a second connection line between the power divider and the second feed. For instance, the power divider 6ac comprises a three port junction connected to a connection line 7a, to another connection line 7c and to an entry line (not illustrated). The power divider 6bd comprises a three port junction connected to a connection line 7b, to another connection line 7d and to an entry line (not illustrated).

The connection line 7c connects the power divider 6ac to the lower end of the footing portion 52c. The connection line 7a connects the power divider 6ac to the lower end of the footing portion 52a.

The connection line 7d connects the power divider 6bd to the lower end of the footing portion 52d. The connection line 7b connects the power divider 6bd to the lower end of the footing portion 52b.

The connection line 7a comprises a $\lambda/2$ connecting portion 7ac. This connecting portion 7ac introduces a 180° phase relative to the connection line 7c.

To equally split the power provided by the power divider 6ac, the impedance amplitudes Zout of the connection lines 7a and 7c are preferably equal. These impedance amplitudes Zout are preferably chosen such that Zout=2*Zin, Zin being the impedance amplitude of the entry line. The entry line will preferably have a Zin impedance amplitude equal to 50 Ω. To balance the amplitude at the input ports of the element feeds, the input power can also be unequally split using connection lines having different impedances. The length of the $\lambda/2$ connecting portion 7ac can be shortened or lengthened to compensate for squint of the far field pattern. Connection lines may be formed using the air microstrip line technology.

In the embodiment illustrated at figure 4, the flanges 41a to 41d are tilted relative to the plane portion 21 of the reflector. The flanges 41a to 41d also form an angle with their respective footings 42a to 42d that differs from 90°. The angle formed between the sidewalls 22 and 23 and the plane surface 21 is higher than 90°.

Figure 5 is a perspective view of another possible shape for flange 41. The flange 41 is provided with a through hole 43. This hole 43 is elongated in a direction that is tangent to the aperture area 8. This hole 43 has a rectangular shape. The radiating portion 3 using such a monopole 4 provides an improved front-to-back ratio.

Figures 6 and 7 illustrate two alternative shapes for the monopoles 4. In these embodiments, each flange 41 is fitted with at least one wing protruding therefrom in the upper direction and being tilted relative to this flange 41. The radiating portion 3 using such a monopole 4 provides an increased impedance bandwidth. This design helps to adapt the impedance bandwidth performance (VSWR) of the radiating element 1 to the far field pattern bandwidth

In the embodiment illustrated at figure 6, only one wing 44 is protruding from the flange 41. Both the flange 41 and the wing 44 have a rectangular shape with a through hole in their middle portion. The wing 44 is tilted relative to the surface of the flange 41.

In the embodiment illustrated at figure 7, two wings 44 and 45 are protruding from the flange 41. Wings 44 and 45 are tilted relative to the surface of the flange 41. The angle between both wings 44 and 45 and flange 41 are different. Both the flange 41 and the wings 44 and 45 have a rectangular shape with a through hole in their middle portion. Any other number of extending wings may be made on flange 41. The flange and the wings can be formed in a single metal piece by appropriate cuts and bendings.

By avoiding metal to metal contacts between the monopoles and the feeds, the risk of passive intermodulation (PIM) can be minimized, so that the PIM stability requirement of <-150dBc with 2*43dBm tones can be fulfilled.

The illustrated radiating element 1 only comprises a radiating portion 3 but radiating elements including several aligned radiating portions can also be made according to the invention.

The illustrated radiating monopoles 4 are independent parts but can also be made as a one-piece component.

The illustrated flange portions 51a to 51d are rectangular. However, other shapes can also be foreseen, notably a trapezoid shape.

CLAIMS

1. Dual polarised radiating element for a cellular base station antenna, comprising:

- a reflector surface for reflecting radiation energy,
- four radiating monopoles distributed around an aperture area, each radiating monopole comprising a footing protruding from said reflector surface and a flange located above the reflector surface and protruding from said footing radially towards the outside, the flanges from adjacent monopoles extending radially perpendicular to each other,
- four element feeds comprising each a footing portion and a flange portion connected to the upper part of the respective footing portion and perpendicular thereto, where each footing portion is capacitively coupled to a respective monopole at the level of its footing and each flange portion protruding radially from respective radiating monopole within the aperture area,
- powering means connected to the element feeds.

2. Dual polarised radiating element according to claim 1, wherein a pair of opposite element feeds extends above the reflector surface between two opposite footings.

3. Dual polarised radiating element according to any of claims 1 and 2, wherein said powering means comprises:

-a power divider,
-a first connection line connecting the power divider to an element feed,
-a second connection line connecting the power divider to an opposite element feed and introducing a 180° phase relative to said first connection line.

4. Dual polarised radiating element according to claim 3, wherein said first and second connection lines have identical impedance amplitudes.

5. Dual polarised radiating element according to any of claims 1 to 4, wherein said reflector surface is plane and wherein said flanges are comprised within a common plane surface, said flanges being parallel to the reflector surface.

6. Dual polarised radiating element according to any of claims 1 to 4, wherein said flanges are tilted relative to said reflector surface.

7. Dual polarised radiating element according to any of the preceding claims, wherein each monopole further comprises at least one wing extending from a respective flange and being tilted relative to this flange.

8. Dual polarised radiating element according to claim 7, wherein said footings have a rectangular shape having the same length as said flanges.

9. Dual polarised radiating element according to any of the preceding claims, wherein said flanges are provided with through holes extending tangentially relative to said aperture area.

10. Dual polarised radiating element according to any of the preceding claims, further comprising sidewalls protruding from said reflector surface on the same side as the radiating monopoles, said radiating monopoles being located between said sidewalls.

11. Dual polarised radiating element according to claim 10, wherein the intersection between the reflector surface and the lateral sidewalls form parallel lines and wherein each pair of opposite element feeds extend according to a direction forming approximately 45° with said parallel lines.

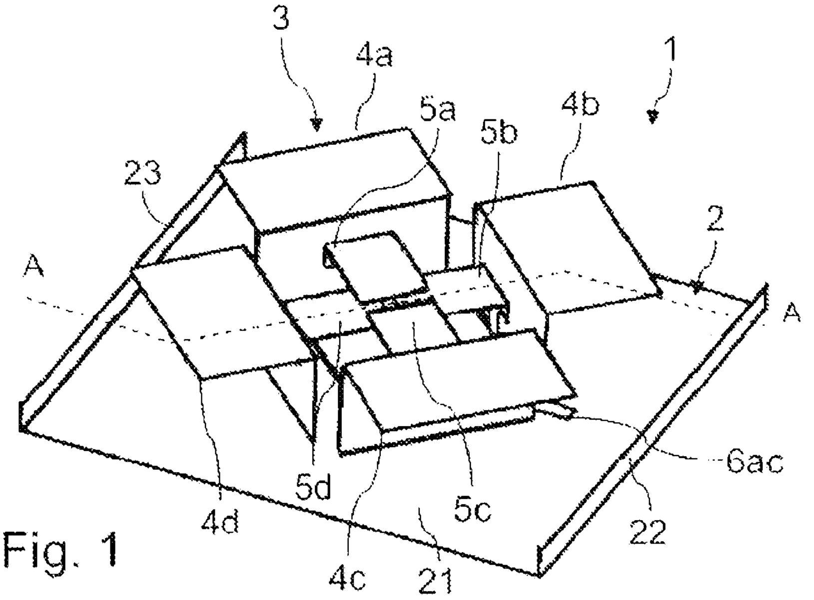


Fig. 1

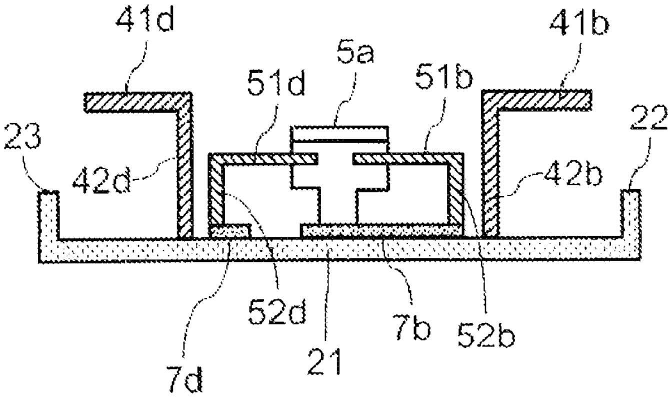


Fig. 2

A-A

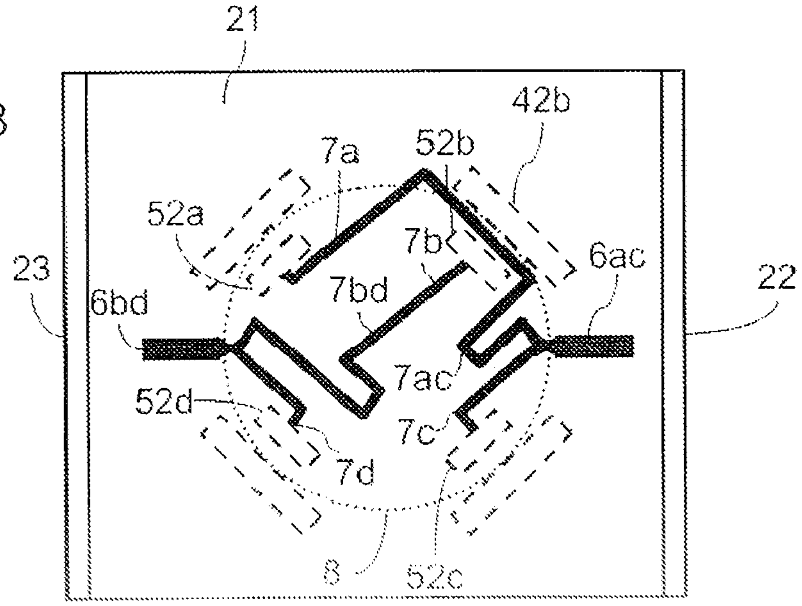
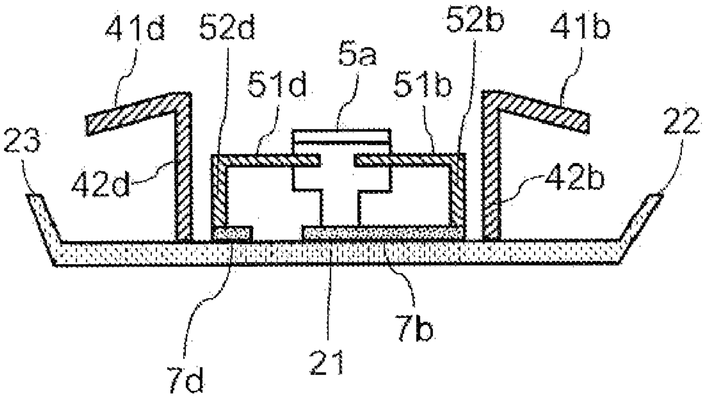


Fig. 3

Fig. 4



A-A

Fig. 5

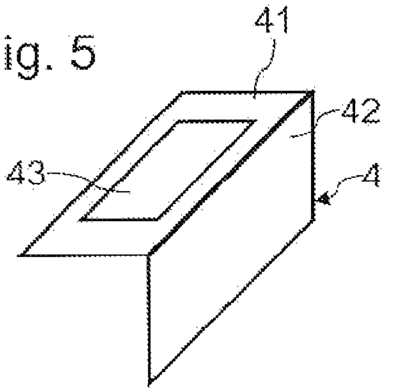


Fig. 6

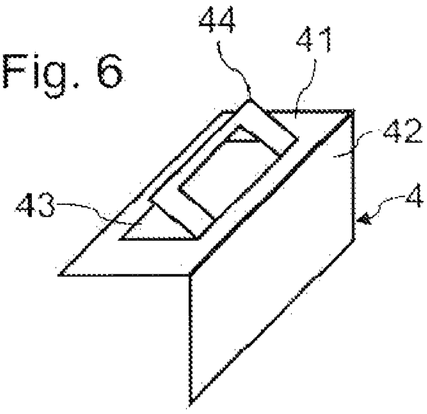


Fig. 7