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(54) **ULTRA BROAD BAND DUAL POLARIZED RADIATING ELEMENT FOR A BASE STATION ANTENNA**

(57) The invention refers to a radiating element for a base station antenna, the radiating element comprising: a support structure, at least a pair of dipole arms in a first layer of the support structure, and at least two parasitic arms in a second layer of the support structure, wherein the distance between the first and the second layer is between 0.0004 and 0.1, preferably between 0.002 and 0.02, of the minimum wavelength of the operating frequency band of the radiating element, wherein the area of the parasitic arms in a projection perpendicular from the second to the first layer cover at least 60% of the areas of the at least one pair of dipole arms.

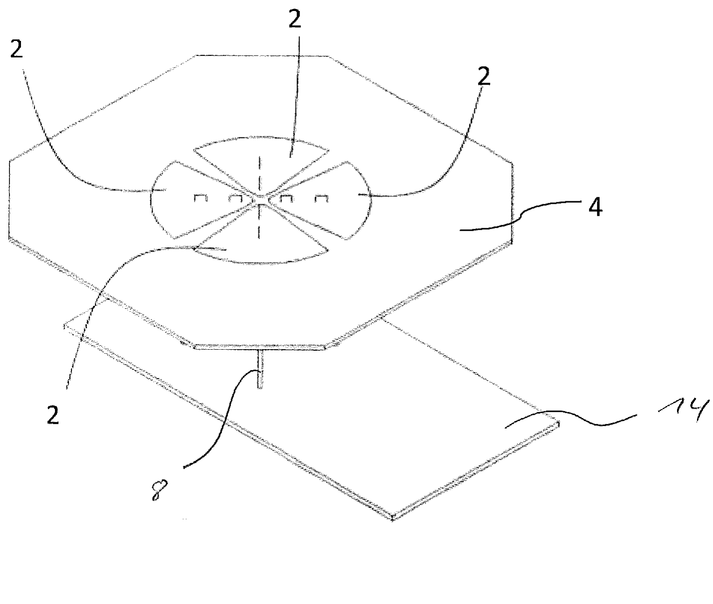

FIG. 1

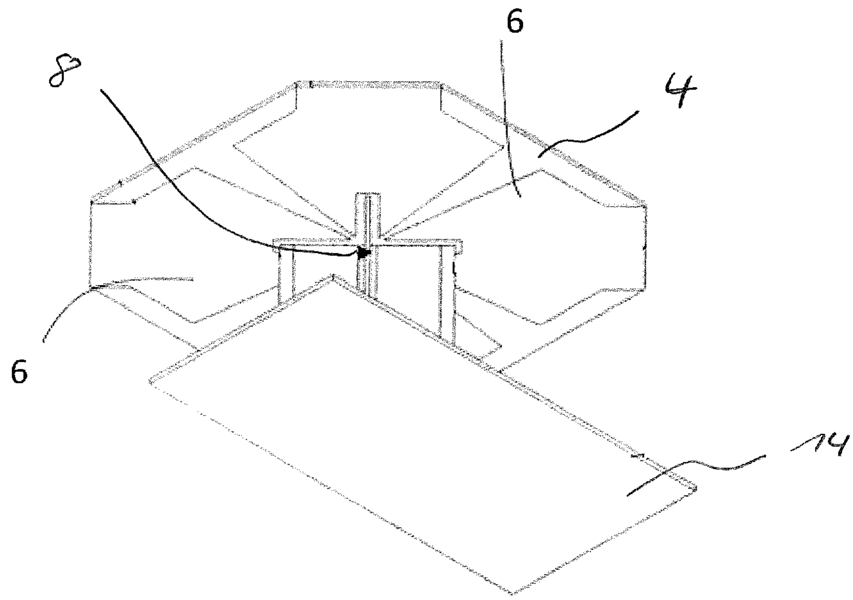

FIG. 2

Description

TECHNICAL FIELD

[0001] The present invention relates to a radiating element for a base station antenna, a dual band radiating arrangement and a base station antenna.

BACKGROUND

[0002] Ultra broad band base station antenna systems typically operate in the 690-960 MHz ("Low Band" - LB), 1.427-2.4 GHz ("Middle Band" - MB) and 1.7-2.7 GHz ("High Band" - HB) spectrum which includes most cellular network frequency bands used today. With the growing demand for a deeper integration of antennas with Radios, e.g. Active Antenna Systems (AAS), new ways of designing ultra compact ultra broadband multiple arrays base antenna architectures by reducing the depth are being requested without compromising the antenna key points.

[0003] For those architectures the coexistence of multiple LB, MB and HB is preferred. However, this becomes even more challenging when trying to reduce the overall geometrical antenna dimensions (compact design) and keeping RF key performance. Among many other technical design strategies, one of the key points is the radiating elements design for the LB, MB and HB. Ideally they should be electrically invisible to each other. From this perspective the physical dimensions of the radiating elements are one of the dominating factors.

[0004] In a typical scenario, the MB frequency range (1.427 GHz - 2.4 GHz) is approximately double the LB frequency range (690 - 960 MHz), therefore a dipole designed to work in the MB will probably resonate and behave as a monopole in the LB, generating unwanted effects and degrading the performance of the antenna in the LB frequency band.

[0005] If the resonant behavior of the MB dipole is not shifted out of the LB frequency band, some unwanted consequences appear from in-band resonance such as peaks in the return loss and isolation, phase discontinuities, disturbances in the radiation pattern, gain drops, etc.

[0006] Hence, there is need for a radiating element that provides a broadband characteristic while having a low profile and being invisible from the other bands coexisting in the antenna.

SUMMARY OF THE INVENTION

[0007] The objective of the present invention is to provide a radiating element for a base station antenna, a dual band radiating arrangement and a base station antenna, which overcome one or more of the above-mentioned problems of the prior art.

[0008] A first aspect of the invention provides a radiating element for a base station antenna, the radiating element comprising: a support structure, at least a pair of dipole arms in a first layer of the support structure, and at least two parasitic arms in a second layer of the support structure, wherein the distance between the first and the second layer is between 0.0004 and 0.1, preferably between 0.002 and 0.02, of the minimum wavelength of the operating frequency band of the radiating element, wherein the area of the parasitic arms in a projection perpendicular from the second to the first layer cover at least 60% of the areas of the at least one pair of dipole arms. The parasitic arms which are formed of a conductive material, arranged in the determined distance with respect to the dipole arms have the technical effect that for the given operating frequency, the total length of the dipole arms can be reduced. Thus, the total dimension of the radiating element in the direction alongside to the dipole arms is decreased with respect to prior art devices. This, for instance, allows to arrange the radiating element in a second radiating element of a lower frequency band to provide a dual-band radiating arrangement in a reduced spatial configuration. The parasitic arms are arranged DC/galvanically isolated from the dipole arms. Each parasitic arms is capacitively coupled to at least one corresponding dipole arm.

[0009] In a first implementation of the radiating element according to the first aspect, the first layer is parallel to the second layer. In general, the distance between the first and second layer which defines the distance between the dipole arms and the parasitic arms in each location can vary within the limits provided according to the first aspect. However, keeping the first layer parallel to the second layer, i.e. the parasitic arms and the dipole arms have a constant vertical distance, is preferred because this configuration can be easily manufactured. For example, the first and second layer may be parallel layers in a continuous support structure of an isolating material. In a second implementation of the radiating element according to any implementation of the first aspect, the support structure comprises a printed circuit board, PCB, and the dipole arms are disposed in a layer of the PCB, and the parasitic arms are disposed in another layer of the same PCB. In this implementation, the support structure is formed by a PCB which can be manufactured cost-efficiently. The first and second layers may be arranged on opposing sides of the PCB. Alternatively, one or more of the first and second layers may also be arranged in an intermediate layer of the PCB.

[0010] In a third implementation of the radiating element according to the first aspect or the first implementation of the first aspect, the support structure comprises or is a molded interconnected device, MID, wherein the dipole arms are formed by a first metallization on the MID and the parasitic arms are formed by a second metallization on the MID, wherein the first metallization and the second metallization are opposite to each other. A support structure out of a MID can also be manufactured cost-efficiently. The metallization which forms the dipole arms and parasitic arms, respectively, may also be arranged in parallel layers such as the top and bottom side of a plan MID plate.

[0011] In a fourth implementation of the radiating element according to the first aspect or the first implementation of the first aspect, the dipole arms are formed by a first set of metal sheets and the parasitic arms are formed by a second set of metal sheets arranged in the distance to the first set of metal sheets. In this implementation, the parasitic arms and dipole arms are made of metal sheets which may be separated by an insulating material. This construction also allows to arrange the parasitic arms and the dipole arms in parallel layers on a support structure which may include any insulating material. In this construction it is not necessary that the insulating material of the support structure is continuously between the parasitic arms and the dipole arms as far as the distance of the first and second layer is within the previously defined limits.

[0012] In a fifth implementation of the radiating element according to any implementation of the first aspect the parasitic arms are floating. Floating means that the arms are isolated from the ground and also not connected any signal feed. In this way, the parasitic arms act effectively as an extension for the dipole arms which decreases the total length of the dipole arms for a given operating frequency.

[0013] In a sixth implementation of the radiating element according to any implementation of the first aspect, the radiating element comprises one or more additional parasitic elements outside the area of the dipole arms and galvanically isolated from the at least two parasitic arms, wherein the additional parasitic elements are arranged in the first, the second or any other layer of the radiating element. Additional parasitic elements outside the area of the dipole arms allow to further decrease the total length of the dipole arms. The additional parasitic elements are also floating and may therefore reduce the total length of the radiating element, i.e. the total length of the dipole arms plus the length added by of the additional parasitic elements arranged outside the dipole arms. The additional parasitic elements may be arranged on any layer of the radiating element, preferably, the parasitic elements are arranged in the first or second layer or on any intermediate layer between the first and second layer. With the additional parasitic elements, in a layer within the predefined distance of the first and second layer, the additional parasitic elements act most efficiently to reduce the length of the dipole arms.

[0014] In a seventh implementation of the radiating element according to any implementation of the first aspect, the at least two parasitic arms each includes a solid area of conductive material. The parasitic arms of a solid area of conductive material are most efficiently for reducing the total length of the dipole arms. However, in other preferred implementations, the area of the conductive material of the parasitic arms may also include non-conductive interruptions. The non-conductive interruptions may affect the radiating characteristics of the radiating element only in a small amount such that the effect of reducing the length of the radiating elements is still provided.

[0015] In an eighth implementation of the radiating element according to any implementation of the first aspect, the support structure comprises a distance holder with a foot for connecting to a reflector of the base station antenna, wherein the distance holder is configured to hold the dipole arms and the parasitic arms at a further predefined distances from the reflector. The support structure including the foot for connecting to a reflector of a base station provides the effect that the dipole arms and the parasitic arms are arranged in a predefined distance to the reflector of the base station antenna. The preferred predefined distance from the reflector in order to keep low profile characteristics and still good RF performance should stay in the range of 0.15 to a quarter wavelength at the central operating frequency. The reflector may act as a reflector for multiple radiating elements in the base station antenna. The feet integrated in the support structure allows to easily connect the radiating elements to the reflector. Moreover, the feet may also include electrical circuitries, in particular a feeding system for the radiating element.

[0016] In a ninth implementation of the radiating element according to any implementation of the first aspect, the distance holder comprises or is a printed circuit board, PCB, perpendicular to the first and second layers of the radiating element, wherein the PCB comprises a balun and a microstrip line, whereas the balun is configured to galvanically connect each of the arms of the at least one pair of dipole arms to ground and whereas the microstrip line is configured to feed, i.e. provide with a signal to be radiated, the at least one pair of dipole arms.. The microstrip line of this implementation acts as a feeding transmission line for the dipole arms. The balun may include a conductive surface on a side of the PCB opposite the microstrip line and its function is to convert the balanced signal of the dipole arms to the unbalanced signal in the feeding line, and vice versa.

[0017] In a tenth implementation of the radiating element according to any implementation of the first aspect, the operating frequency band is in a range from 1.4 GHz to 2.7 GHz. This operating frequency is preferred because it allows to arrange the radiating element of this implementation into a further radiating element which operates in the low band, i.e. in the range from 690 MHz to 960 MHz.

[0018] A second aspect of the invention refers to a dual band radiating arrangement of at least first and second radiating elements, the first radiating element according to any implementation of the first aspect having an operating frequency band and the second radiating element having an operating frequency band lower than the operating frequency band of the first radiating element, wherein the first radiating element is arranged inside the second radiating element. The dual band radiating arrangement according to this aspect has the benefit that the two radiating elements of different bands can be arranged to occupy only a minimum space. This is a particular advantage for the construction of base station antennas which are typically operated in at least two frequency bands such as a first band is covered by the first radiating element and the second band is covered by the second radiating element. As the second radiating element for the lower frequency is necessarily bigger in size, it is an advantage that the radiating element for the upper band can be arranged inside the radiating element for the lower band.

[0019] A third aspect of the invention refers to a base station antenna comprising: a reflector; at least a radiating element of any of the implementations of the first aspect and/or a dual band radiating element according to the second aspect; wherein the radiating element and/or dual band radiating element is arranged before the reflector so that the dipole arms and the parasitic arms are arranged at predefined distances to the reflector. The base station antenna of this aspect may include a plurality of radiating elements and/or dual band radiating elements which are all arranged in the predefined distance to a single reflector. Thus, this construction allows to construct a base station having at least two or three radiating elements for different operating bands within a small spatial configuration.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] To illustrate the technical features of embodiments of the present invention more clearly, the accompanying drawings provided for describing the embodiments are introduced briefly in the following. The accompanying drawings in the following description are merely some embodiments of the present invention, but modifications on these embodiments are possible without departing from the scope of the present invention as defined in the claims.

FIG. 1 shows a perspective view of a radiating element of a first embodiment from the top side,

FIG. 2 shows a perspective view of the radiating element of the first embodiment from the bottom side,

FIG. 3 shows a side elevation view of the radiating element of the first embodiment,

FIG. 4 shows a side elevation view of a PCB including a feeding system of the first embodiment,

FIG. 5 shows a perspective view of a dual band radiating element of a second embodiment from the top side,

FIG. 6 shows a perspective view of the dual band radiating element of the second embodiment from the bottom side,

FIG. 7 shows a plan view on a base station antenna of a third embodiment,

FIGs 8a-c show perspective top views and bottom views of further three embodiments of a radiating element.

Detailed Description of the Embodiments

[0021] Referring to FIGs 1 to 5 a first embodiment of a radiating element is described.

[0022] The radiating element includes two pairs of dipole arms 2 which are capable of radiating in perpendicular polarizations. The dipole arms 2 are arranged on a top surface of a supporting structure which includes in this embodiment a printed circuit board, PCB, 4. The dipole arms 2 are electromagnetically coupled to (but galvanically/DC isolated from) parasitic arms 6 which include a layer of a conductive material and are arranged on the opposing side of the PCB 4. The shape of the parasitic arms is arbitrary but preferably covers the whole area of the respective dipole arms 2. In the shown embodiment, the parasitic arms are arranged on the bottom layer of the PCB and the dipole arms 2 are arranged on the top layer of the PCB 4. However, it should be understood that in other embodiments the dipole arms and the parasitic arms may also be arranged in other layers (top layer, bottom layer or intermediate layer) of a support structure such as a PCB or a modelled interconnected device, MID.

[0023] The dipole arms 2 have a curved profile as shown in FIG. 1. However, other geometries are possible.

[0024] The parasitic arms 6 are floating, i.e. they are galvanically disconnected from the ground and also from any other signal feed.

[0025] The dipole arms 2 are dipole feet 8 which in the present embodiment are formed by two PCBs stacked together.

[0026] With reference to FIGs 3 and 4 more details of the dipole feet 8 are described. The dipole feet 8 of each PCB includes a microstrip line 10 which capacitvely feeds the respective pair of dipole arms 2. Moreover, on the side opposing the side of the microstrip line 10 of the PCB of the dipole foot 8, the surface is metallized to form a balun structure 12. The electrical balun structure 12 is realized by capacitively or as shown in the embodiment galvanically connecting the metallized surface in two points to the dipole arms 2. This allows an additional tuning of the resonance frequency of the dipole arms 2. In other words, the dipole feet 8 provides a capacitive feeding to the dipole arms 2 and furthermore a galvanic connection of the dipole arms 2 to ground.

[0027] Below the dipole feet a further feeding PCB 4 is arranged to serve as an interface between the microstrip lines 10 and antenna feeding network and to provide a mechanical support for the radiating element.

[0028] The relationship between the dipole arms 2 and the coupled parasitic arms 6 are defined as follows: the projection of the dipole arm 2 over the parasitic arm 6 should overlap at least 60% of the surface of the dipole arm 2. The parasitic arm layer should be below the dipole arms at a distance between 0.0004 and 0.1 of the minimum wavelength of the operating frequency band of the radiating element, preferably between 0.002 and 0.02 of the minimum wavelength. The distance may be constant as shown in the first embodiment as the layer of the dipole arms and the layer of the parasitic arms are parallel. However, in other embodiments, the distance may also vary within the given limits.

[0029] The length and area of the parasitic arms 6 determines the bandwidth and the resonance frequency of the radiating element. The parasitic arms 6 can have an arbitrary shape, but preferably the parasitic arms are solid. There are at least two parasitic arms 6 per dipole but other embodiments are not limited to only two parasitic arms per dipole. Additional parasitic arms can be used for further increasing the operational bandwidth of the dipole.

[0030] The radiating element as described above is intended to work in a multiband architecture which will be described in the context of FIGs 5 and 6.

[0031] FIGs 5 and 6 depict of a multiband arrangement of a second embodiment which includes as one part the radiating element of the first embodiment. The first radiating element is arranged inside a cup-shaped radiating element 20 of a lower frequency. For example, the radiating element of the first embodiment may operate in the middle band while the second radiating element 20 of the dual band radiating arrangement operates in the low band. Further details regarding the second radiating element 20 of the low band are described in the parallel pending PCT patent application PCT/EP2016/057963 which is fully incorporated by reference. It is obvious that the dual band radiating arrangement of the second embodiment is optimized for the available space as the radiating element for the middle band is arranged inside the radiating element 20 of the low band.

[0032] The lower frequency radiating element 20 acts as a sub reflector for the first radiating element arranged inside the lower frequency radiating element. To ground the first radiating element to a sub reflector, an orthogonal PCB of the lower band radiating element is capacitively coupled to a lower plane of the lower frequency radiating element 20.

[0033] As shown in FIG. 6, the combined radiating element is fed also through the crossed PCBs 8 which also forms the feet of the first radiating element. Further details are described in the mentioned parallel pending PCT patent application PCT/EP2016/057963

[0034] Referring to FIG. 7, a base station antenna of a third embodiment is described. The base station antenna includes a reflector 30 and a plurality of radiating elements. Along a centreline of the reflector 30, first radiating elements and dual band radiating elements according to the second embodiments are arranged. Moreover, a third type of radiating elements are arranged on the longitudinal sides of the reflector 30. The third type of radiating elements have an operating band of the high band, i.e. from 1710 to 2690 Mhz.

[0035] As shown in FIG. 7, the total arrangement of the base station antenna is spatially optimized as the radiating elements of the low band and the middle band are embodied in part by dual band radiating elements as described before. All radiating elements act with the same reflector 30.

[0036] With reference to FIGs 8a to 8c, further embodiments of radiating elements are described. FIG. 8a shows a radiating element similar to the first embodiment but the parasitic element includes a non-conductive interruption 40 within the solid area of conductive material. The embodiment of FIG. 8b includes two parasitic arms 42 for each dipole arm. The amount of the area of the two parasitic arms 42 cover at least 60% of the area of the dipole arm. The embodiment of FIG. 8c includes additional parasitic elements 44. The additional parasitic elements 44 are arranged on the top side of the PCB in the same layer of the dipole arms 2. The additional parasitic elements 42 further increase the operational band frequency of the dipole.

[0037] The foregoing descriptions are only implementation manners of the present invention, the scope of the present invention is not limited to this. Any variations or replacements can be easily made through person skilled in the art. Therefore, the protection scope of the present invention should be subject to the protection scope of the attached claims.

Claims

1. A radiating element for a base station antenna, the radiating element comprising:

a support structure,
at least a pair of dipole arms (2) in a first layer of the support structure (4), and
at least two parasitic arms (6) in a second layer of the support structure (4),
wherein the distance between the first and the second layer is between 0.0004 and 0.1, preferably between 0.002 and 0.02, of the minimum wavelength of the operating frequency band of the radiating element,
wherein the area of the parasitic arms in a projection perpendicular from the second to the first layer cover at least 60% of the areas of the at least one pair of dipole arms (2).

2. The radiating element according to claim 1, wherein the first layer is parallel to the second layer.

3. The radiating element according to any of the previous claims, wherein the support structure (4) comprises a printed circuit board, PCB, and wherein the dipole arms (2) are disposed in a layer of the PCB, and the parasitic arms (6) are disposed in another layer of the same PCB.

4. The radiating element according to claim 1 or 2, wherein the support structure (4) comprises or is an molded interconnected device, MID, wherein the dipole arms (2) are formed by a first metallization on the MID and the parasitic arms are formed by a second metallization on the MID, wherein the first metallization and the second metallization are opposite to each other.

5. The radiating element according to claim 1 or 2, wherein the dipole arms (2) are formed by a first set of metal sheets and the parasitic arms (6) are formed by a second set of metal sheets arranged in the distance to the first set of metal sheets.

6. The radiating element according to any of the previous claims, wherein the parasitic arms (6) are floating.

7. The radiating element according to any of the previous claims comprising one or more additional parasitic elements outside the area of the dipole arms (2) and galvanically isolated from the at least two parasitic arms (6), wherein the additional parasitic elements (44) are arranged in the first, the second or any other layer of the radiating element.

8. The radiating element according to any of the previous claims wherein the at least two parasitic arms (6) each includes a solid area of conductive material.

9. The radiating element of any previous claim, wherein the support structure comprises a distance holder with a foot for connecting to a reflector (30) of the base station antenna, wherein the distance holder is configured to hold the dipole arms (2) and the parasitic arms (6) at a further predefined distance from the reflector.

10. The radiating element of any of the previous claims wherein the distance holder comprises or is a printed circuit board, PCB, perpendicular to the first and second layers of the radiating element, wherein the PCB comprises a balun (12) and a microstrip line (10), whereas the balun (12) is configured to galvanically connect each of the arms of the at least one pair of dipole arms (2) to ground and whereas the microstrip line is configured to feed the at least one pair of dipole arms (2).

11. The radiating element according to any of the preceding claims, wherein the operating frequency band is in a range from 1.4 GHz to 2.7 Ghz.

12. A dual band radiating arrangement of at least first and second radiating elements (20), the first radiating element according to any of the previous claims having an operating frequency band and the second radiating element (20) having an operating frequency band lower than the operating frequency band of the first radiating element, wherein the first radiating element is arranged inside the second radiating element (20).

13. A base station antenna comprising:

a reflector (30);
at least a radiating element of any of the claims 1 to 11 and/or a dual band radiating element according to claim 12;
wherein the radiating element and/or dual band radiating element is arranged before the reflector (30) so that the dipole arms (2) and the parasitic arms (6) are arranged at predefined distances to the reflector (30).

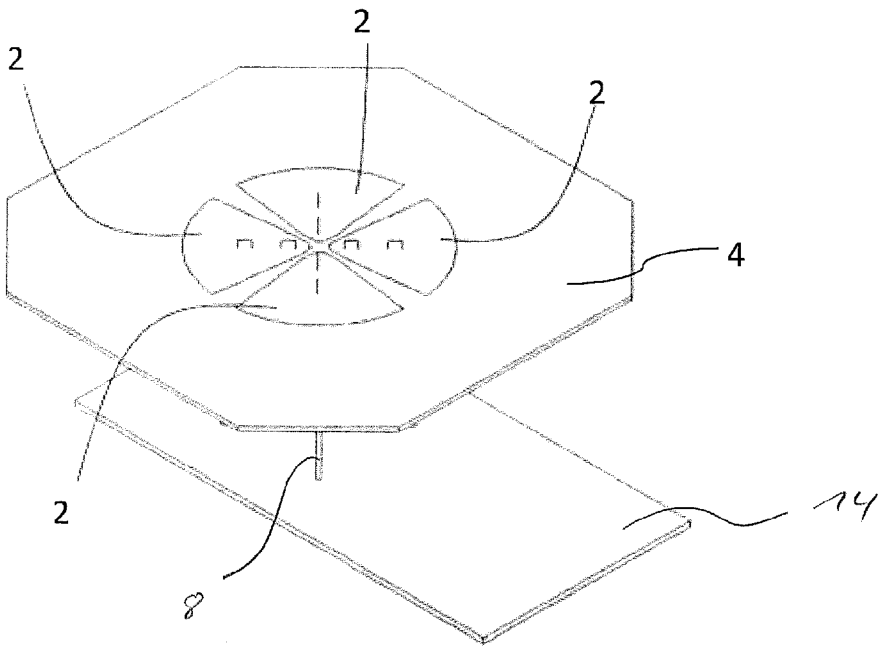

FIG. 1

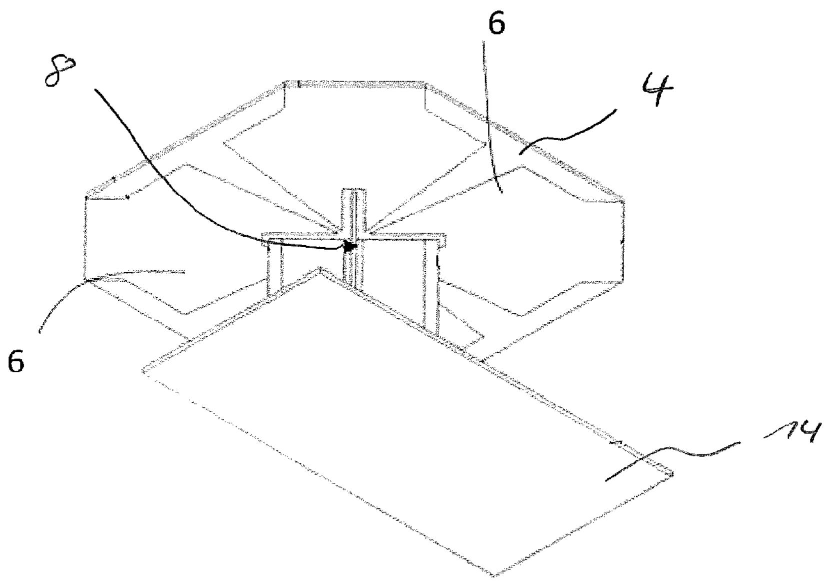

FIG. 2

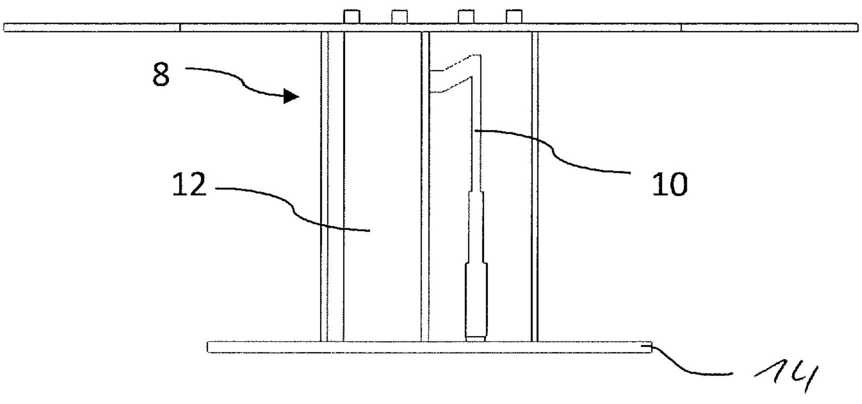

FIG. 3

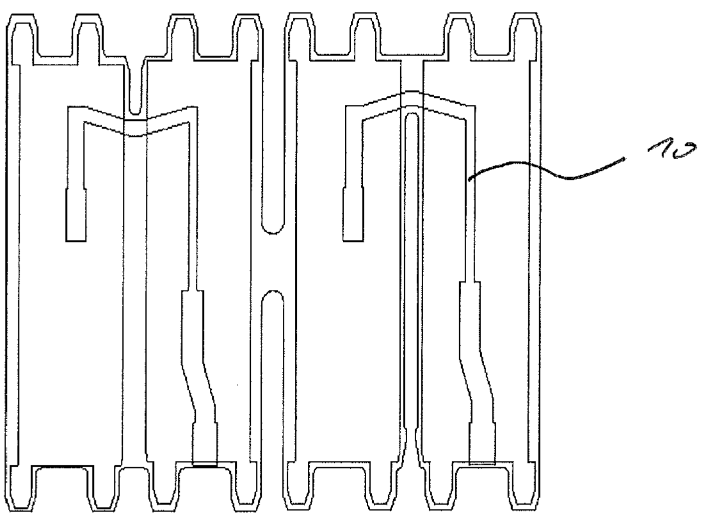

FIG. 4

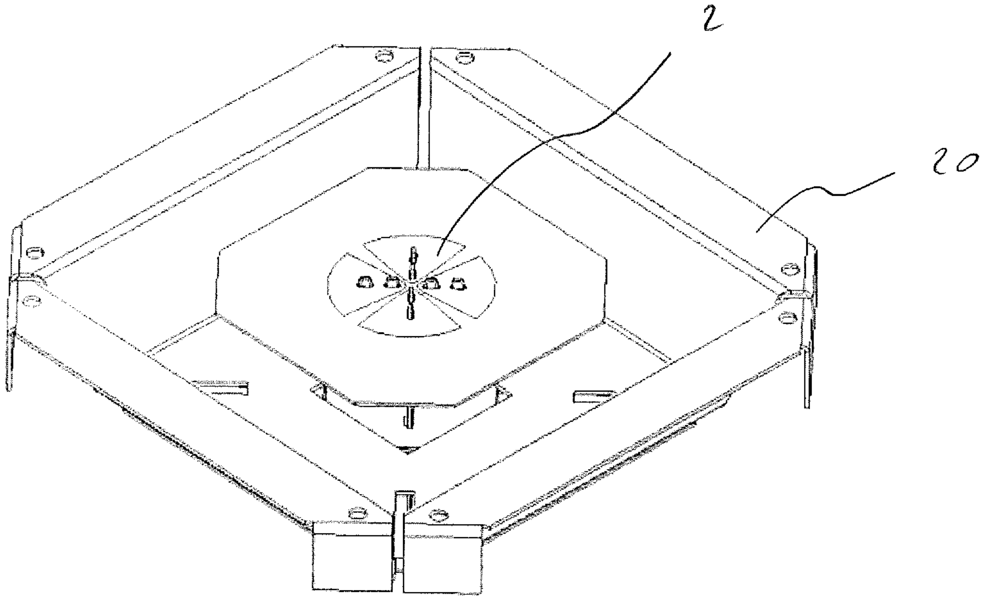

FIG. 5

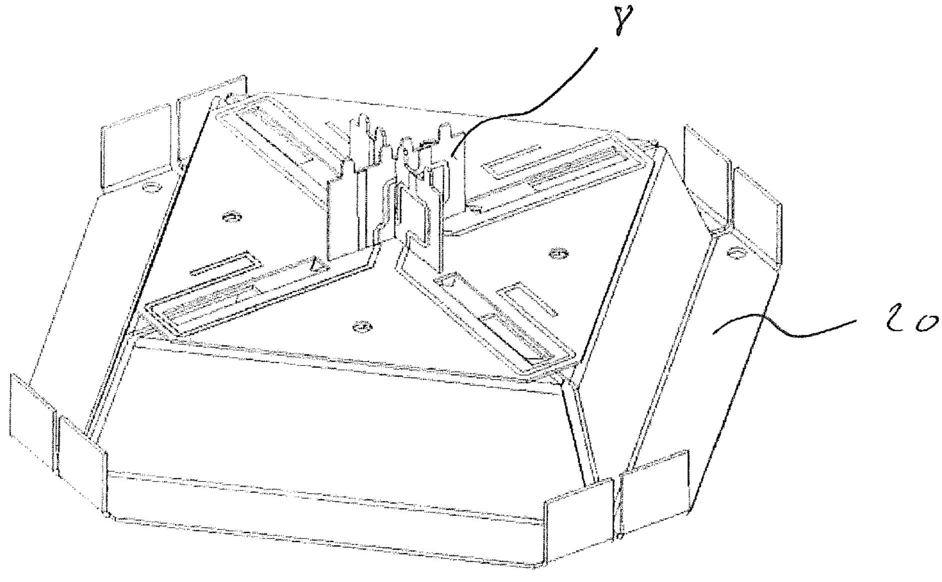

FIG. 6

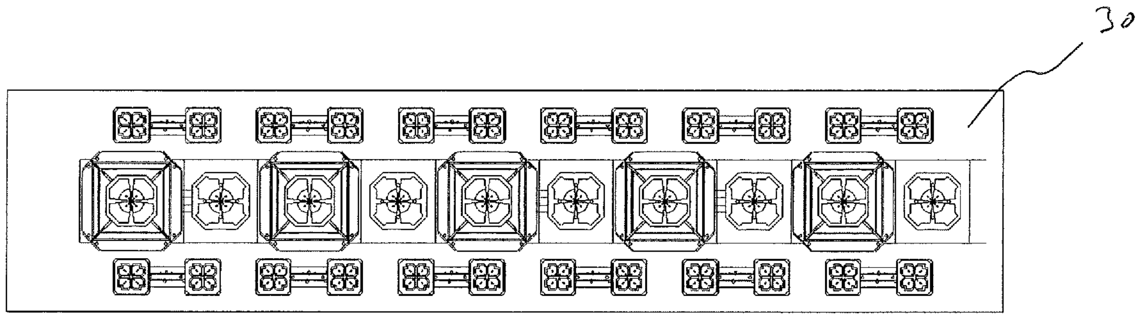

FIG. 7

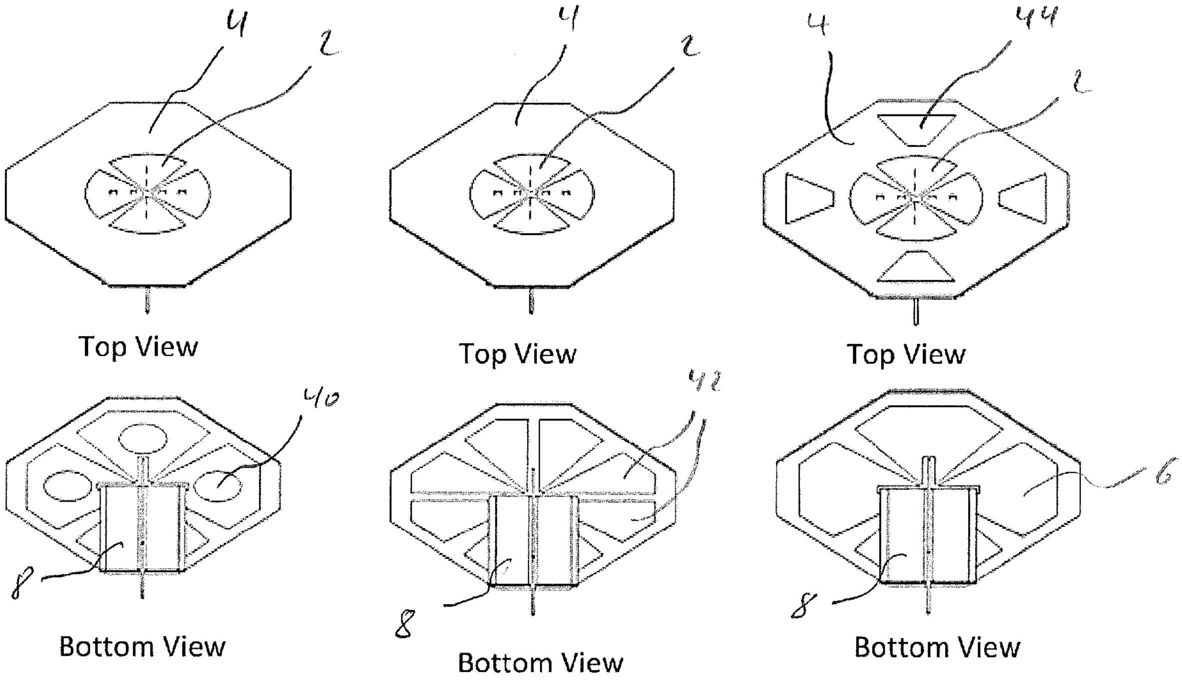

FIG. 8a

FIG. 8b

FIG. 8c

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EUROPEAN SEARCH REPORT

Application Number
EP 16 16 4812

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 6 342 866 B1 (HO THINH Q [US] ET AL) 29 January 2002 (2002-01-29) * column 2, line 29 - column 3, line 41; figure 1 * * column 4, line 6 - column 4, line 26; figure 7 * -----	1-8, 11-13 9,10	INV. H01Q1/24 H01Q1/38 H01Q9/06 H01Q5/357 H01Q5/385 H01Q19/10 H01Q21/28 ADD. H01Q21/06 H01Q21/24
Y	EP 2 378 610 A1 (COMBA TELECOM SYSTEM CHINA LTD [CN]) 19 October 2011 (2011-10-19) * column 4, paragraph 33 - column 6, paragraph 41; figures 1-3 * * column 7, paragraph 50 - column 7, paragraph 51; figure 6 * -----	1-13	
Y	WO 2014/009697 A1 (ANTRUM LTD [GB]) 16 January 2014 (2014-01-16) * page 8, line 6 - page 9, line 2; claims 1-5; figures 1, 3, 4 * * page 9, line 3 - page 9, line 11; figure 5 * * page 10, line 26 - page 10, line 29; figure 9 * -----	1-13	TECHNICAL FIELDS SEARCHED (IPC) H01Q
A	DIVYA UNNIKRISHNAN ET AL: "Microstrip transmission lines and antennas on Molded Interconnect Devices materials", 2013 13TH MEDITERRANEAN MICROWAVE SYMPOSIUM (MMS), 1 September 2013 (2013-09-01), pages 1-4, XP055307270, DOI: 10.1109/MMS.2013.6663072 ISBN: 978-1-4673-5820-0 * section III.; figures 12, 13 * ----- -/--	4	

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	5 October 2016	Blech, Marcel

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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D : document cited in the application
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EPO FORM 1503 03.82 (P04C01)

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EUROPEAN SEARCH REPORT

Application Number
EP 16 16 4812

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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