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(54) **A MULTI-PORT SLOT ANTENNA WITH GROUND CONTINUITY**

(57) When a multi-port slot antenna exhibits disjoint ground planes for the different ports due to the arrangements of the slots, a salient idea is to use high impedance lines loaded by discrete RF inductors for connecting the different grounds related to the different ports of the multi-port slot antenna. The inductor exhibits a very low im-

pedance from a Direct Current (DC) point of view and very high impedance (several hundreds to few kilos of Ohms) at the operating Radio Frequency (RF). Hence, this will achieve a continuous DC ground without affecting the RF performance of the antenna.

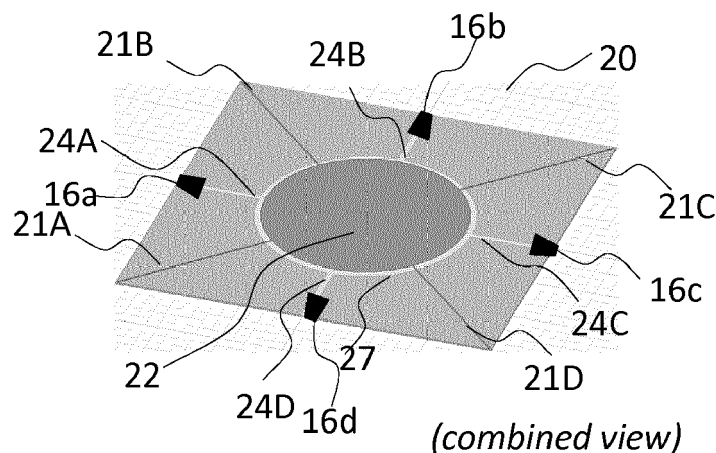


Figure 2C

Description

1. TECHNICAL FIELD

[0001] The present disclosure relates to an antenna adapted to be integrated in an apparatus for receiving a digital signal, and more particularly a broadcast television signal using multiple inputs multiple outputs technology.

2. BACKGROUND ART

[0002] A slot antenna consists of a metalized surface with one or more holes or slots cut out. When the metalized surface is driven as an antenna by a driving frequency, the slot radiates electromagnetic waves in a way similar to a dipole antenna. The shape and the size of the slot determine the radiation pattern. A multi-port slot antenna is an antenna where the metalized surface can be driven by multiple inputs and can be a possible implementation of a MIMO (Multiple Input Multiple Output) system. However, when such a multi-port slot antenna is realized in a printed circuit board with the slots splitting the ground plane into multiple disconnected ground planes, integrating active electronic components to the different ports of the antenna is challenging. A possible approach is to connect each active electronic component driving each port of the antenna by an additional wire for carrying the ground in addition to the wire carrying the driving signal. But adding such ground wires in the vicinity of the antenna may significantly affect the functioning of the antenna and increase the coupling to the RF noise coming from neighbouring hardware. The present disclosure has been designed with the foregoing in mind.

3. SUMMARY

[0003] When a multi-port slot antenna exhibits disjoint ground planes for the different ports due to the arrangements of the slots, a salient idea is to use high impedance lines loaded by discrete RF inductors for connecting the different grounds related to the different ports of the multi-port slot antenna. The inductor exhibits a very low impedance from a Direct Current (DC) point of view and very high impedance (several hundreds to few kilos of Ohms) at the operating Radio Frequency (RF). Hence, this will achieve a continuous DC ground without affecting the RF performance of the antenna.

[0004] A first aspect of the disclosure is related to a new multi-port slot antenna topology. The antenna comprises

- a first conductive surface fed by a plurality of conductive tracks;
- at least one slot splitting a second conductive surface in at least a first and a second disjoint sub-parts, each of the first sub-part and the second sub-part being a ground plane for a different conductive track, wherein the first and the second sub-parts are con-

nected by a RF inductor.

[0005] A second aspect of the disclosure is directed to a device for receiving communication signals, the device comprising the antenna according to the first aspect.

4. BRIEF DESCRIPTION OF THE DRAWINGS

[0006]

- **Figures 1A, 1B, 1C, 1D and 1E** show two multi-port slot antennas according to two non-limiting exemplary embodiments of the disclosed principles
- **Figure 2A** shows a top view of a Multi-port Hybrid Slot (MHS) antenna according to a non-limiting third exemplary embodiment of the disclosed principles;
- **Figure 2B** shows a bottom view of a Multi-port Hybrid Slot (MHS) antenna according to a non-limiting third exemplary embodiment of the disclosed principles;
- **Figure 2C** shows a combined view in perspective of a Multi-port Hybrid Slot (MHS) antenna according to a non-limiting third exemplary embodiment of the disclosed principles;
- **Figure 2D** shows a top view of a Multi-port Hybrid Slot (MHS) antenna according to a non-limiting fourth exemplary embodiment of the disclosed principles using triangular slots;
- **Figure 2E** shows a bottom view of a Multi-port Hybrid Slot (MHS) antenna according to a non-limiting fourth exemplary embodiment of the disclosed principles using triangular slots;
- **Figure 2F** shows a combined view in perspective of a Multi-port Hybrid Slot (MHS) antenna according to a non-limiting fourth exemplary embodiment of the disclosed principles using triangular slots;
- **Figure 2G** shows a Multi-port Hybrid Slot (MHS) antenna according to a non-limiting fourth exemplary embodiment of the disclosed principles in a perspective view with size information;
- **Figure 2H** shows an expanded portion of the Multi-port Hybrid Slot (MHS) antenna depicted in Figure 2F according to a non-limiting fourth exemplary embodiment of the disclosed principles.

[0007] It should be understood that the drawing(s) are for purposes of illustrating the concepts of the disclosure and are not necessarily the only possible configuration for illustrating the disclosure.

5. DESCRIPTION OF EMBODIMENTS

[0008] The present description illustrates the principles of the present disclosure. All examples and conditional language recited herein are intended for educational purposes to aid the reader in understanding the principles of the disclosure and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited exam-

ples and conditions.

[0009] Moreover, all statements herein reciting principles, aspects, and embodiments of the disclosure, as well as specific examples thereof, are intended to encompass both structural and functional equivalents thereof. Additionally, it is intended that such equivalents include both currently known equivalents as well as equivalents developed in the future, i.e., any elements developed that perform the same function, regardless of structure. Thus, for example, it will be appreciated by those skilled in the art that the diagrams presented herein represent conceptual views of illustrative circuitry embodying the principles of the disclosure.

[0010] Figures 1A, 1B, 1C, 1D and 1E show two multi-port slot antennas according to two non-limiting exemplary embodiments of the disclosed principles. Figure 1A illustrates a common top view of the antenna according to both embodiments. Figure 1B illustrates a first bottom view and Figure 1C a first combined view (together with the common top view) of the antenna according to a first embodiment of the disclosed principles. Figure 1D illustrates a second bottom view and Figure 1E a second combined view (together with the common top view) of the antenna according to a second embodiment of the disclosed principles.

[0011] Referring to Figure 1A, the top side 10A of the multi-port slot antenna comprises a first conductive surface 13 fed by a plurality of conductive tracks 11, 12 within a non-conductive substrate 100. The conductive tracks 11, 12 are connected to the first conductive surface 13 and are the ports of the antenna. Outer extremities of the conductive tracks are feeding points where the signal driving the antenna is input or output. Figure 1A shows an antenna with two ports 11, 12, but any higher number of ports of the multi-port antenna are compatible with the disclosed principles.

[0012] Referring to Figure 1B the bottom side 10B of the multi-port slot antenna is a conductive ground plane split by a slot 15 into two disjoint subparts 101b, 102b. The term "slot" is used throughout the disclosed principles to refer to a hole cut out for example of a metalized surface thus breaking the electrical continuity. In case the antenna is realized in a printed circuit board (PCB), a slot is a non-conductive area etched in a conductive area within a same layer of the PCB.

[0013] Referring to Figure 1C showing the combination of the top view and the bottom view of the multi-port slot antenna 10C according to a first embodiment of the disclosed principles, each of the first subpart 101b and the second subpart 102b of the ground plane is a standalone ground plane for a different conductive track 11, 12. More precisely, the first subpart 101b is a first ground plane for the first conductive track 11, and the second subpart 102b is a second ground plane for the second conductive track 12, the first ground plane 101b being disconnected from the second ground plane 102b. Whenever active components need to be integrated to the ports 11, 12 of the antenna 10C, a reference to a

common ground plane is needed. A possible approach is to connect each active electronic component driving each port of the antenna by an additional wire for carrying the ground in addition to the wire carrying the driving signal. But adding such ground wires in the vicinity of the antenna may significantly affect the functioning of the antenna and increase the coupling to the RF noise coming from neighbouring hardware. Another approach would be to connect both sub planes by a short circuit over the slot 15. This however would lead to a major deterioration of the antenna performance in comparison with the initial design (i.e. with disconnected ground planes). The short circuit indeed drastically changes the slot geometry and impacts its radiation properties. The two ground sub planes are advantageously connected by a RF (Radio Frequency) inductor 16 exhibiting a very low impedance (less than a few ohms) from a DC point of view and a very high impedance (several hundreds to few kilo of Ohms) at the RF operating frequency of the antenna. The value of the RF inductor (L) is for example chosen so that its reactance is higher than 500Ω at the lowest frequency of interest (f_L). In other words, the value of the inductor is given by $L=R/(2\pi*f_L)$, equivalent to $L=80/f_L$ for $R=500\Omega$, where the unit of inductance is given in henry (SI symbol: H) and the frequency in hertz (SI symbol: Hz). The frequencies of interest represent the operating frequency band of the antenna. 500Ω is given as a possible example, other neighbouring values are of course possible. Connecting the ground sub plane by such a RF inductor allows to provide a continuous DC ground without affecting the RF performances of the antenna by keeping the slot property unchanged within the operating frequency of the antenna.

[0014] According to a specific and non-limiting embodiment of the disclosed principles, the multi-port slot antenna is a printed circuit board antenna comprising a first layer and a second layer, the first layer comprising the first conductive surface 13 and the plurality of conductive tracks 11, 12, the second layer comprising the second conductive surface split into the first subpart 101b and the second subpart 102b by at least one slot 15. Other arrangements such as 3D antennas are also compatible with the disclosed principles, which are not limited to PCB antennas.

[0015] Figure 1D and Figure 1E illustrate a multi-port slot antenna according to a second embodiment of the disclosed principles. Referring to Figure 1D, the bottom side 10D of the multi-port slot antenna is a conductive ground plane comprising an elliptic annular slot 17, extended towards two opposite edges of the PCB via two straight slots 18, 19. The elliptic annular slot 17 extended by the straight slots split the conductive ground plane into three disjoint ground sub planes 101d, 102d and 103d. The disclosed principles are not limited to an annular slot and any central non-conductive surface extended via at least two slots towards at least two edges (not necessarily opposite) of the antenna, splitting the conductive ground plane into at least two disjoint ground sub

planes is compatible with the disclosed principles.

[0016] Referring to **Figure 1E** showing the combination of the top view 10A, depicted at **Figure 1A** and the bottom view 10D depicted at **Figure 1D** of the multi-port slot antenna 10E according to a second embodiment of the disclosed principles, each of the first subpart 101d and the second subpart 102d of the ground plane is a standalone ground plane for a different conductive track 11, 12. More precisely, the first subpart 101d is a first ground plane for the first conductive track 11, and the second subpart 102d is a second ground plane for the second conductive track 12, the first ground plane 101b being disjoint from the second ground plane 102d. The second embodiment suffers from the same drawbacks as the first embodiment regarding the two disjoint ground sub planes. The subpart 103d is also disjoint from the first and second subparts 101 d, 102d. In a first variant, the third subpart only having a minor area facing the first or the second conductive track, is not considered as a ground plane for any of the antenna ports, and the multi-port slot antenna 10E only comprises a single RF inductor 16 connecting the first subpart 101d and the second subpart 102d of the ground plane, the RF inductor 16 exhibiting a very low impedance from a DC point of view and a very high impedance at the RF operating frequency of the antenna. In a second variant (not represented) and considering the third subpart 103d as a ground plane for at least one of the ports, the multi-port slot antenna further comprises at least one additional RF inductor for interconnecting the third subpart 103d to the first and/or the second subparts.

[0017] **Figures 2A, 2B, 2C** show a Multi-port Hybrid Slot (MHS) antenna according to a non-limiting third exemplary embodiment of the disclosed principles. **Figure 2A** illustrates a top view, **Figure 2B** a bottom view and **Figure 2C** a combined view in perspective. In this embodiment, four ports 21A, 21B, 21C, 21D are used. Other embodiments using less ports (for example two or three) or more ports such as six or eight to adapt to other kinds of applications are also compatible with the disclosed principles. According to the third embodiment, the MHS antenna 20 is a printed circuit board antenna comprising a first layer 20A and a second layer 20B separated by a non-conductive substrate. In the third embodiment, the first layer is on top and the second layer is on the bottom. The first layer 20A comprises a plurality of conductive tracks 21A, 21B, 21C, 21D feeding a central conductive surface 22, i.e. the conductive tracks being connected to the central conductive surface. Outer extremities of the conductive tracks, thus on the edge of the printed circuit board, are feeding points where the signal is input. The first layer 20A is for example made of a non-conductive substrate 23, on which the conductive tracks such as microstrip lines 21A, 21B, 21C, 21D and a central conductive surface 22 are printed. The central conductive surface 22 is a metallized surface of any shape, for example a disc shape as illustrated in figures 2A, 2B, 2C. The second layer 20B comprises a central non-conduc-

tive surface 26 embedded in a conductive surface 25. In other words, the conductive surface 25 surrounds the central non-conductive surface 26. The second layer 20B further comprises a plurality of slots 24A, 24B, 24C, 24D that are non-conductive and extend from the central non-conductive surface 26 to the edge of the printed circuit board. The central non-conductive surface and the slots are for example etched from a fully conductive layer. In other words, the second layer 20B is fully conductive except the surface 26 and the slots 24A, 24B, 24C, 24D being etched in the conductive layer. According to a specific and non-limiting embodiment of the disclosed principles, one of either the central conductive surface 22 of the first layer 20A or the central non-conductive surface 26 of the second layer 20B is surrounding the other, the central conductive surface 22 and the central non-conductive surface 26 being centred in the plane of the printed circuit board antenna 20. An interval 27 between the central conductive surface 22 of the first layer 20A and the central non-conductive surface 26 of the second layer 20B results from one of either of these surfaces being surrounding the other. By "surrounding" it is meant here and throughout the document that one surface is overlapping the other in the plane of the PCB: when looking at projections of both surfaces in the plane of the PCB, one projected surface is completely included in the other and the difference between both surfaces creates an interval. The interval 27 between the central conductive surface 22 of the first layer 20A or the central non-conductive surface 26 of the second layer 20B of the PCB antenna behaves as a slot antenna by radiating electromagnetic waves. However, although behaving as a slot, the interval 27 differs from a slot since an interval is a hole between conductive surfaces of different layers while a slot is a hole within a conductive surface of same layer.

[0018] In order to benefit from a homogeneous interval, the shapes of the central conductive surface 22 of the first layer 20A and of the central non-conductive surface 26 of the second layer 20B are identical, but only of different sizes. In another embodiment, the shape identity is not required but a shape similarity is sufficient, for example one of the surface being a disc and the other being a (filled) oval.

[0019] The term central utilized herein is an abuse of language since in this context it does not necessarily indicate that the central surface is positioned at the exact center of the printed circuit board but rather indicates that the central surface is positioned away from the edges, although not at the same distance of the edges.

[0020] The sizing of the antenna is so that the conductive circular disc 22 of the first layer 20A and the non-conductive circular disc slot 26 of the second layer 20B are aligned in the (x,y) plane, while the diameter of the second is for example 10 mm larger than the diameter of the first and so that the interval 27 generated between the circular disc etched on one side of the substrate and the circular slot realized on the other side presents

almost the same dimensions as the slot of a regular annular slot antenna, for example of 5mm.

[0021] As for the first and the second embodiments, the central non-conductive surface 26 extended towards the edges of the PCB antenna by the plurality of slots 24A, 24B, 24C, 24D splits the conductive ground plane 25 into four disjoint sub-planes 201b, 202b, 203b, 204b for respectively the different ports 21A, 21B, 21C, 21D. The four disjoint ground sub-planes 201b, 202b, 203b, 204b are connected one to one by four RF inductors 16a, 16b, 16c, 16d similarly to the first and the second embodiments. As seen in former embodiments, connecting the ground sub plane by such RF inductors allows to provide a continuous DC ground without affecting the RF performances of the antenna by keeping the slot properties unchanged within the operating frequency of the antenna.

[0022] Figures 2D, 2E, 2F show a Multi-port Hybrid Slot (MHS) antenna according to a non-limiting fourth exemplary embodiment of the disclosed principles using triangular slots. Figure 2D illustrates a top view, figure 2E a bottom view and figure 2F a combined view in perspective. In this embodiment, four ports are used. Other embodiments using less ports (for example two or three), or more ports such as six or eight to adapt to other kind of applications are also compatible with the disclosed principles. The fourth embodiment is very similar to the third embodiment and uses almost the same elements arranged identically. The difference is the shape of the slots. While antenna of the third embodiment used straight slots on its second layer, the antenna 27 of fourth embodiment uses slots 28A, 28B, 28C, 28D that have a triangular shape whose base are located on the edge of the printed circuit board and that are directed to the circular central non-conductive surface 28. This shape provides better decorrelation between the radiation patterns corresponding to the different inputs and better antenna efficiency. As for the third embodiment, the central non-conductive surface 28 extended towards the edges of the PCB antenna by the plurality of triangular slots 28A, 28B, 28C, 28D split the conductive ground plane into four disjoint sub-planes 201e, 202e, 203e, 204e for respectively the different ports 21A, 21B, 21C, 21D. The four disjoint ground sub-planes 201e, 202e, 203e, 204e are connected one to one by four RF inductors 16a, 16b, 16c, 16d similarly to the first, the second and the third embodiments.

[0023] Figure 2H shows an expanded view of a portion of the antenna 29 illustrated in Figure 2F. Figure 2H shows how two disjoint ground sub-planes 203e, 204e are connected by the RF inductor 16c at the edge of the PCB. The slots are triangular and based at edges of the PCB splitting a ground plane in at least two disjoint sub-planes. Contrary to the previous embodiment with straight slots, for which the connection of two sub-planes by a RF inductor was straight forward, here since the slots are triangular, several variants are possible for connecting two sub-planes by a RF inductor. In a first variant,

the triangular slot goes up to the edge of the PCB and two microstrip lines interconnected by the RF inductor 16c are added along the edge of the PCB on top of the base of the triangular slot 28C. In a second variant the triangular slot does not go up the edge of the PCB keeping a conductive line along the edge of the PCB between the base of the triangular slot and the edge of the PCB, the conductive line being disrupted by a non-conductive portion into two segments. The two segments are interconnected by the RF inductor similarly as for the first variant. In both variants, the RF inductor 16c exhibits a very low impedance from a DC point of view and a very high impedance at the RF operating frequency of the antenna. Although Figure 2H shows two microstrip lines of equal size the RF inductor 16c being located at the middle of the base of the triangular slot, the disclosed principles are not limited this arrangement, et micro-strip lines of different sizes interconnected by a RF inductor at any location on the base of the triangular slot is compatible with the disclosed principles. In any of the variant, the two microstrip lines connected with the RF inductor differ from a short circuit as they remain behaving as an open circuit in the operating frequency band of the antenna.

[0024] Figure 2G shows a Multi-port Hybrid Slot (MHS) antenna according to a non-limiting fourth exemplary embodiment of the disclosed principles in a perspective view with size information. In this embodiment, the overall size of the printed circuit board is 280mm by 280mm. The central conductive surface of the top layer is circular and has a diameter of 160mm while the central non-conductive surface of the bottom layer is also circular and has a diameter of 170mm thus creating an interval that is 5mm wide. The conductive tracks of the top layer are 2.375mm wide. The triangular slots of the bottom layer have a base of 30mm and are 2.25mm wide at the area where they meet the circular central non-conductive surface

[0025] In all the PCB related embodiments described herein, the antenna is printed on a FR4 (Flame Resistant 4) substrate ($\epsilon_r = 4.2$, $\tan(\delta) = 0.02$) with a thickness of 1.041mm. The PCB is a square of 280mm by 280mm.

[0026] According to another embodiment, the shape of both the central conductive surface of top layer and central non-conductive surface of the bottom layer are not circular but are in the shape of a triangle, a square, a polygon, a star, an oval, an ovoid or other quirkier forms.

[0027] According to a specific and non-limiting embodiment, the antenna is designed for a central frequency around 600MHz, corresponding for example to a digital terrestrial transmission frequency band. According to that embodiment the value of the RF inductor is 560nH. The PCB antenna, according to any corresponding embodiment and/or variant previously described is a square of 280mm by 280mm, the diameter of the conductive disc (conductive surface) is for example 160 mm, and the diameter of the non-conductive disc is 170 mm. This antenna design is for example well suited for being integrated in digital TV receivers so that the TV receivers, with

integrated MHS antenna are adapted for an indoor TV reception without requiring any external or outdoor antenna. The integration a MHS antenna directly in a digital TV receiver allows for easier deployment of digital TV receivers by avoiding the need of any external outdoor antenna solution. The MHS antenna is further compatible with other frequency bands and suited for being integrated in other communications devices such as cell phones, Wi-Fi devices, and wireless access points of any wireless standard. According to another specific and non-limiting embodiment, the antenna is designed for a central frequency around 5GHz, for example corresponding to Wi-Fi devices. To a first approximation, the dimensions of antenna are adapted to another frequency band by applying a ratio on its dimensions corresponding to the ratio of the central frequencies (here for example 600/5000). According to this specific and non-limiting embodiment, a MHS antenna designed for the 5GHz band would fit in a PCB square of 36 mm by 36 mm and the diameters of the conductive disc and non-conductive discs being respectively of 19 mm and 20.5 mm, resulting in an interval of 1.5mm. Such an antenna device can be integrated in wireless devices such a cell phones, tablets, set-top-boxes, Wi-Fi cards or Wi-Fi access points. Any MHS antenna design with dimensions adapted to a targeted frequency is compatible with the disclosed principles.

[0028] According to a specific and non-limiting embodiment of the disclosed principles a new multi-port slot antenna topology is disclosed. The antenna comprises a first conductive surface fed by a plurality of conductive tracks. The antenna further comprises at least one slot splitting a second conductive surface in at least a first and a second disjoint subparts, each of the first and the second subpart being a ground plane for a different conductive track, wherein the first and the second sub-parts are connected by a RF inductor.

[0029] According to a variant, the antenna is a printed circuit board antenna comprising a first layer and a second layer, the first layer comprising the first conductive surface and the plurality of conductive tracks, the second layer comprising the second conductive surface and the at least one slot.

[0030] According to another variant, the second layer further comprises a central non-conductive surface extended towards at least two edges of the printed circuit board by the at least one slot

[0031] According to another variant, the central conductive surface of first layer and the central non-conductive surface of the second layer have similar shape with different sizes to create an interval between the surfaces that behaves as a slot antenna by radiating electromagnetic waves.

[0032] According to another variant, at least one of slots of the second layer is triangular, whose base is located on the edge of the printed circuit board and directed to the central non-conductive surface.

[0033] According to another variant, the central conductive surface of first layer and the central non-conduc-

tive surface of the second layer are shaped in the form of a disc.

[0034] According to another variant, the number of conductive tracks is one among two, three, four, five, six, seven and eight.

[0035] According to another variant, outer extremities of the conductive tracks are located in corners of the printed circuit board.

[0036] According to another variant, for at least one conductive track, the outer extremity of the at least one conductive track is located at an edge of the printed circuit board between a corner and the center of the edge of the printed circuit board.

[0037] According to another variant, the shape of the central conductive surface of first layer and the non-conductive central of the second layer is one among a triangle, a square, a polygon, a star, an oval and an ovoid.

[0038] According to another variant, the RF inductor has an inductance greater or equal than 560 nH.

[0039] According to another variant, the conductive surfaces are printed on the printed circuit board.

[0040] According to another variant, the non-conductive surfaces are etched into the printed circuit board.

[0041] According to another variant, the size of the interval is 5mm for broadcast television reception or 1.5mm for Wi-Fi reception.

[0042] While not explicitly described, the present embodiments may be employed in any combination or sub-combination. The present principles are not limited to the described shape examples for the central conductive surface and any other type of shape is compatible with the disclosed principles. The present principles are further neither limited to printed circuit board antennas nor to the described numbers of layers of the printed circuit board antenna and are applicable to any arrangement of 3D antenna and/or to any number of layers of a printed circuit board antenna. The present principles are further not limited to the described shape, number, position and length of the slots extending the central non-conductive surface towards the edges of the printed circuit board antenna, and are applicable to any other shape, number, position and length of the slots.

Claims

1. A multi-port slot antenna (10C, 10E, 20, 29) comprising:

- a first conductive surface (13, 22) fed by a plurality of conductive tracks (11, 12, 21A, 21B, 21C, 21D);
- at least one slot (15, 17-18-19, 26-24A-24C, 28-28A-28C) splitting a second conductive surface in at least a first (101b, 101e, 201b, 201e) and a second (102b, 102e, 202b, 202e) disjoint subparts, each of the first and the second subpart being a ground plane for a different conduc-

tive track, wherein the first and the second sub-parts are connected by a RF inductor (16, 16a, 16b, 16c, 16d).

2. The antenna according to claim 1, wherein the antenna is a printed circuit board antenna comprising a first layer and a second layer, the first layer comprising the first conductive surface (12, 22) and the plurality of conductive tracks (11, 12, 21A, 21B, 21C, 21D), the second layer comprising the second conductive surface and the at least one slot. 5
3. The antenna according to claim 2, wherein the second layer further comprises a central non-conductive surface (17, 26, 28) extended towards at least two edges of the printed circuit board by the at least one slot (18-19, 24A-24C, 28A-28C). 10
4. The antenna according to claim 3, wherein the central conductive surface (22) of first layer and the central non-conductive surface (26, 28) of the second layer have similar shape with different sizes to create an interval between the surfaces that behaves as a slot antenna by radiating electromagnetic waves. 15
5. The antenna according to claim 4 wherein at least one of slots (28A, 28B, 28C, 28D) of the second layer is triangular, whose base is located on the edge of the printed circuit board and directed to the central non-conductive surface. 20
6. The antenna according to claim 4 or 5 wherein the central conductive surface of first layer (22) and the central non-conductive surface (26, 28) of the second layer are shaped in the form of a disc. 25
7. The antenna according to any of claims 1 to 6 where the number of conductive tracks is one among two, three, four, five, six, seven and eight. 30
8. The antenna according to any of claims 1 to 6 wherein outer extremities of the conductive tracks are located in corners of the printed circuit board. 35
9. The antenna according to any of claims 1 to 8 wherein, for at least one conductive track, the outer extremity of the at least one conductive track is located at an edge of the printed circuit board between a corner and the center of the edge of the printed circuit board. 40
10. The antenna according to any of claims 1 to 9 wherein the shape of the central conductive surface of first layer and the non-conductive central of the second layer is one among a triangle, a square, a polygon, a star, an oval and an ovoid. 45
11. The antenna according to any of claims 1 to 10 50

wherein the RF inductor has an inductance greater or equal than 560 nH.

12. The antenna according to any of claims 1 to 11 wherein the conductive surfaces are printed on the printed circuit board. 5
13. The antenna according to any of claims 1 to 12 wherein the non-conductive surfaces are etched into the printed circuit board. 10
14. The antenna according to any of claims 1 to 13 wherein the size of the interval is 5mm for broadcast television reception or 1.5mm for Wi-Fi reception. 15
15. A device for receiving communications, the device comprising the antenna according any one of the claims 1 to 14. 20

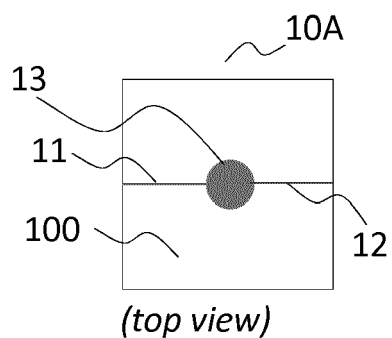


Figure 1A

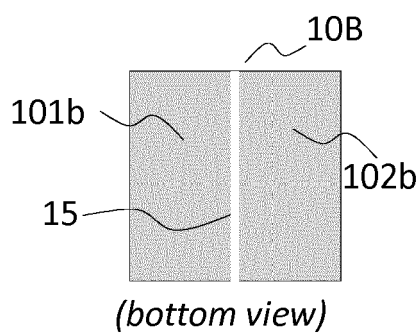


Figure 1B

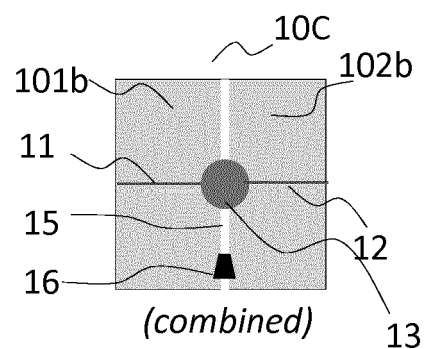


Figure 1C

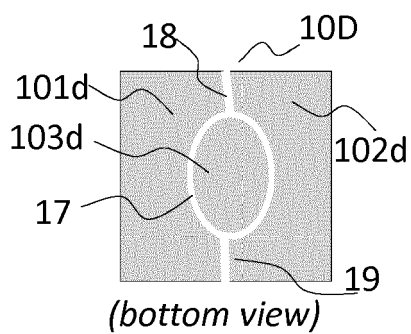


Figure 1D

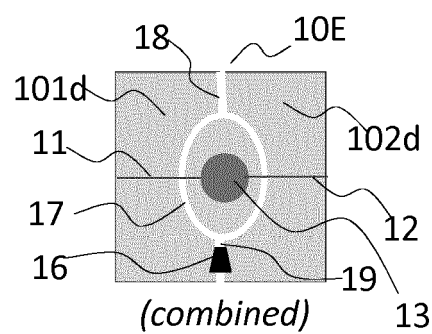


Figure 1E

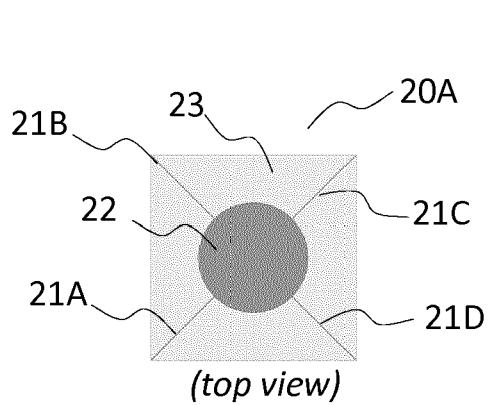


Figure 2A

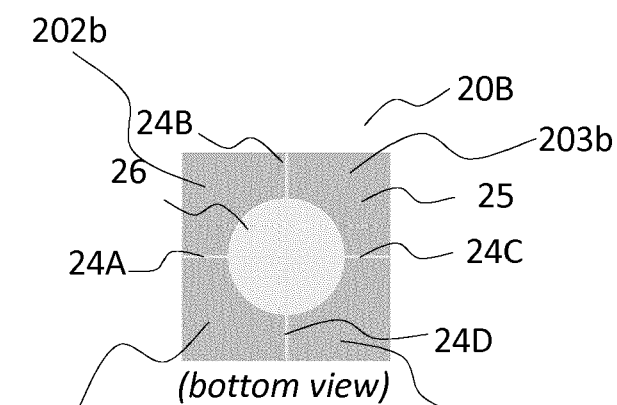


Figure 2B

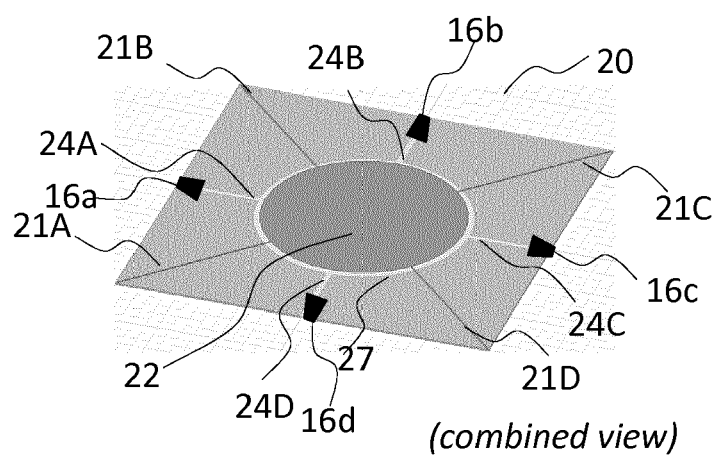
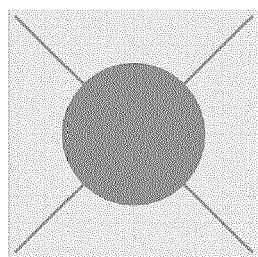
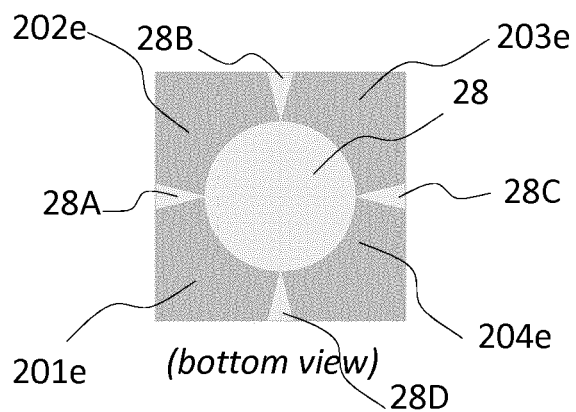


Figure 2C



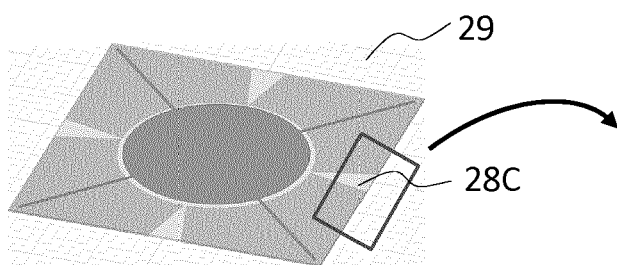
(top view)

Figure 2D



(bottom view)

Figure 2E



(combined view)

Figure 2F

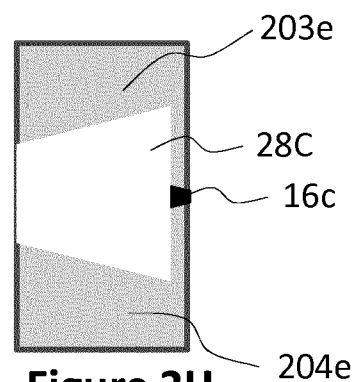


Figure 2H

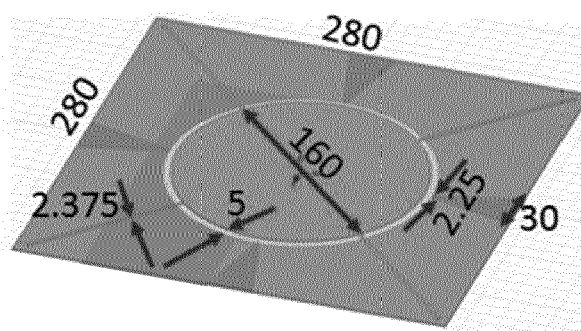


Figure 2G



EUROPEAN SEARCH REPORT

Application Number
EP 18 30 5667

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Y	* column 1, lines 38-68; figures 1,2 * * column 2, lines 41-68 * * column 3, lines 27-68 * * column 4, lines 1-14 *	1-4,6,10	H01Q13/10 H01Q21/28
Y	----- JIANG XIAOLEI ET AL: "Planar dual-polarized UWB antenna with common aperture and high isolation", 2013 IEEE ANTENNAS AND PROPAGATION SOCIETY INTERNATIONAL SYMPOSIUM (APSURSI), IEEE, 7 July 2013 (2013-07-07), pages 21-22, XP032556459, ISSN: 1522-3965, DOI: 10.1109/APS.2013.6710671 ISBN: 978-1-4799-3538-3 [retrieved on 2014-01-13] * section II; page 21, left-hand column, lines 1-14; figure 1 *	1-4,6,10	
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Place of search The Hague		Date of completion of the search 5 November 2018	Examiner Georgiadis, A
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The members are as contained in the European Patent Office EDP file on
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