(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 240 105 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
01.11.2017 Bulletin 2017/44

(21) Application number: **16305483.6**

(22) Date of filing: **25.04.2016**

(51) Int Cl.:
H01Q 1/22 *(2006.01)* ***H01Q 1/44*** *(2006.01)*
H01Q 1/48 *(2006.01)* ***H01Q 9/42*** *(2006.01)*

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(71) Applicant: **Thomson Licensing**
92130 Issy-les-Moulineaux (FR)

(72) Inventors:
- **LO HINE TONG, Dominique**
  35576 CESSON-SÉVIGNÉ (FR)
- **GLAIS, Laurent**
  35576 CESSON-SÉVIGNÉ (FR)
- **LE FOULGOC, Jean-Marc**
  35576 CESSON-SÉVIGNÉ (FR)

(74) Representative: **Novagraaf Technologies**
12 Place des Halles Saint Louis
56100 Lorient (FR)

(54) APPARATUS INCLUDING THE ANTENNA DEVICE

(57) The present invention relates to an antenna device (1) comprising a metal inverted-F antenna to be mounted onto a printed circuit board, said metal inverted-F antenna being arranged for radiating radiofrequency signals in a predetermined frequency band and said printed circuit board including a feeding port and a ground port. According to embodiments of the invention, the metal inverted-F antenna (1) is further arranged for interconnecting the ground port of the printed circuit board to a metal plate separate from the printed circuit board.

Thus, the metal inverted-F antenna acts both as a radiating element and as an interconnecting element. It plays both the role of an antenna and the role of an interconnecting element between a printed circuit board and a metal plate.

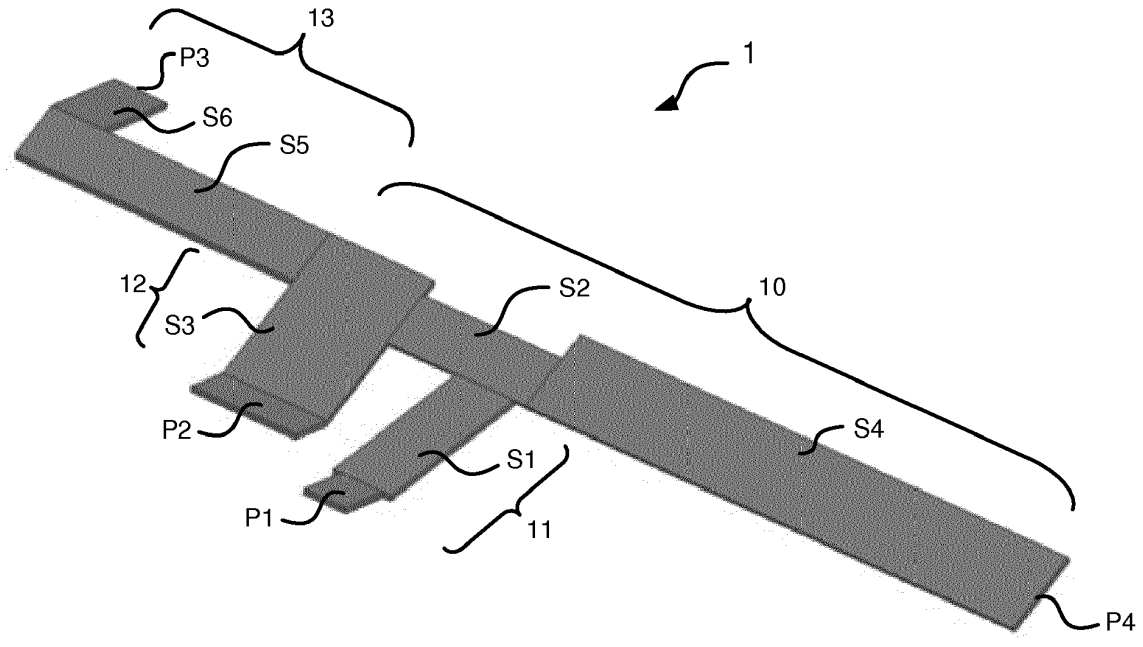

FIG.1

EP 3 240 105 A1

Description

1. Technical Field

[0001] The present invention relates generally to the field of antenna devices or antenna structures.

2. Background Art

[0002] Lots of multimedia devices now comprise one or several antennas for exchanging data signals with other multimedia devices. Such multimedia devices may for example comprise one or several WiFi antennas and one or several Bluetooth antennas. These antennas are connected to dedicated printed circuit boards for processing the data signals. All these components are generally to be integrated in a small volume. The multimedia device is generally completed with metal parts that enable to mitigate the met electromagnetic compatibility (EMC), electromagnetic interferences (EMI), and electrostatic discharge (ESD) issues and to comply with regulation specifications. All the printed circuit boards (PCBs) have to be interconnected together using dedicated connectors, like PCIe connectors. The PCBs have also to be interconnected to the additional metal parts which can both serve as heat spreaders and as a global grounding reference.

[0003] All these interconnections require dedicated connectors or clips and contribute to increase the product cost.

3. Summary of Invention

[0004] According to embodiments of the invention, it is proposed to create an antenna both acting as a radiating element and as an interconnecting element.

[0005] A first aspect of the invention relates to an antenna device comprising a metal inverted-F antenna to be mounted onto a printed circuit board, said metal inverted-F antenna being arranged for radiating radiofrequency signals in a predetermined frequency band and said printed circuit board including a feeding port and a ground port. According to the invention, the metal inverted-F antenna is further arranged for interconnecting the ground port and the ground plane of the printed circuit board to a metal plate separate from the printed circuit board.

[0006] Thus, the metal inverted-F antenna plays both the role of an antenna and the role of an interconnecting element between a printed circuit board and a metal plate. It enables the cost and size of the device to be reduced.

[0007] In a particular embodiment, the metal inverted-F antenna comprises a radiating element, a feeding element and a ground element arranged together to have an inverted-F shape and a connecting element having a first end both connected to the ground element and the radiating element and a second end to be connected to the metal plate.

[0008] In a particular embodiment, the connecting element comprises a first portion in line with the radiating element.

[0009] In a particular embodiment, the connecting element comprises a second portion for connecting said first portion to the metal plate.

[0010] In a particular embodiment, the first and second portions of the connecting element are perpendicular.

[0011] In a particular embodiment, the ground element, the feeding element, the radiating element and the connecting element are coplanar.

[0012] In another particular embodiment, the ground element, the feeding element, the radiating element and the connecting element are not coplanar.

[0013] In a particular embodiment, the inverted-F antenna resonates at a resonant frequency in the predetermined frequency band and wherein the total length of the ground element and the radiating element is substantially equal to $\lambda/4$, where λ designates the wavelength associated to said resonant frequency.

[0014] In a particular embodiment, the length of the connecting element is comprised between $\lambda/8$ and $\lambda/4$.

[0015] Another aspect of the invention concerns an apparatus comprising the antenna device defined hereinabove. Thus the invention also relates to an apparatus comprising:

- a printed circuit board comprising a ground port,
- a separate metal plate,
- a metal inverted-F antenna mounted onto the printed circuit board as defined in the antenna device defined hereinabove.

[0016] In a particular embodiment, the printed circuit board comprises a ground plane and the inverted-F antenna comprises a radiating element, a feeding element and a ground element. These elements are arranged such that the radiating element does not overlap the ground plane of the printed circuit board.

[0017] In a particular embodiment, the printed circuit board and the metal plate are not coplanar.

[0018] In a particular embodiment, the printed circuit board and the metal plate are substantially perpendicular.

[0019] In a particular embodiment, the metal plate is a grounding reference plate.

[0020] In a particular embodiment, the metal plate is a heat spreading element.

[0021] Embodiments of the invention can help to reduce the cost of a multimedia device comprising at least one antenna, one printed circuit board and one separate metal plate(s) to be connected to the printed circuit board, and to reduce the number of components of such multimedia device.

[0022] While not explicitly described, the present embodiments may be employed in any combination or sub-combination.

4. Brief description of the drawings

[0023] The invention may be better understood with reference to the following description and drawings, given by way of example and not limiting the scope of protection, and in which:

- FIG.1 is a perspective view of an antenna device according to an embodiment of the invention;
- FIG.2 is a perspective view of an apparatus according to an embodiment of the invention comprising a printed circuit board, a metal plate and the antenna device of FIG.1;
- FIG.3 is a top view of the apparatus of FIG.2;
- FIG.4 is a side view of the apparatus of FIG.2;
- FIG.5 is a diagram illustrating the return loss of the antenna device of FIG.1;
- FIG.6 is a diagram illustrating the peak gain response of the antenna device of FIG.1;
- FIG.7 is a diagram illustrating the efficiency response of the antenna device of FIG.1; and
- FIG.8 is a 3D diagram illustrating the radiation pattern of the antenna device of FIG.1 in the apparatus of FIG.2.

5. Description of a preferred embodiment

[0024] FiG.1 is a perspective view of an antenna device according to an embodiment of the invention. The antenna device is a kind of pseudo inverted-F antenna 1 with two ground pins, one ground pin to be connected to a ground plane of a printed circuit board and one ground pin to be connected to a metal plate serving as a grounding reference and/or as heat spreading element. The antenna has been designed to work in the Bluetooth band.

[0025] The pseudo inverted-F antenna 1 comprises a plurality of metal strips, S1 to S6, forming a radiating element (or main radiating element) 10, a feeding element 11 and a ground element 12 arranged together to have an inverted-F shape and a connecting element 13 to be connected to the metal plate. The antenna also comprises one feeding pin P1, two ground pins P2 and P3 and one open-circuit pin P4.

[0026] Basically, the radiating element 10 is formed by the two metal strips S2 and S4 which are aligned. The feeding element 11 is formed by the metal strip S1 which is substantially perpendicular to the metal strips S2 and S4 and the ground element 12 is formed by the metal strip S3 which is substantially perpendicular to the metal strips S2 and S4 and parallel to the metal strip S1.

[0027] The feeding element 11 comprises the feeding pin P1 at its free end. Similarly the ground element 12 comprises the feeding pin P2 at its free end.

[0028] According to this embodiment of the invention, the antenna 1 comprises a connecting element 13 formed by the metal strips S5 and S6. The metal strip S5, which constitutes a first portion of the connecting element 13, is connected to the strip S3 of the ground element and is in line with the strips S2 and S4 of the radiating element. The metal strip S6, which constitutes a second portion of the connecting element 13, is connected to the free end of the strip S5. In the present embodiment, the strips S5 and S6 are perpendicular.

[0029] The dimensions (size and length) of the strips S1 to S6 are defined to match the required impedance and the required frequency band. Examples of dimensions are given in the following table for an antenna device working in the Bluetooth or Wi-Fi 2.4GHz band:

Table 1

Metal Strip	Length (mm)	Width (mm)
S1	5.5	2.5
S2	6	2
S3	5.9	4.5
S4	21	3
S5	12	2
S6	3	2.5

[0030] These dimensions are defined such that the total length of the strips S2, S3 and S4 forming the ground element 12 and the radiating element 10 is substantially equal to $\lambda/4$, where λ designates the wavelength associated to the resonant frequency of the antenna. 9. The length of the connecting element 13 is substantially equal to $\lambda/8$ but it can be comprised between $\lambda/8$ and $\lambda/4$.

[0031] This antenna device has been designed to be integrated in an apparatus comprising a printed circuit board 2 and a metal plate 3 as shown in FIGs.2 to 4. The printed circuit board 2 is adapted to process the signals received by the antenna device 1 or to generate the signals to be emitted though the antenna device 1.

[0032] In these drawings, the printed circuit board 2 and the metal plate 3 are substantially perpendicular. The antenna device 1 serves both as an antenna for the printed circuit board 2 and as interconnecting element for connecting the ground port of the printed circuit board 2 to the metal plate 3.

[0033] The metal plate 3 can serve as a grounding reference and as a heat spreader for the overall electronic device.

[0034] The feeding pin P1 and the ground pin P2 of the antenna device are connected to a feeding port and a ground port of the printed circuit board 2. The ground pin P3 of the antenna device is connected to the metal plate 3.

[0035] As can be seen in Figs.2 to 4, the printed circuit board 2 is positioned lower than the upper edge of the metal plate. The antenna device thus comprises bended parts to compensate this difference of levels. The ends of the ground element 12 and the feeding element 11 are bended to form the ground pin P2 and the feeding P1, respectively. Assuming that the plane of the printed circuit board 2 is horizontal, these end portions and the strip S6 are also horizontal while the other strips S1 to S5 are positioned in one or more inclined planes.

[0036] As can be seen in Fig. 4, the strips S1 and S3 do not belong to the same inclined plane. These strips have different angles compared to the PCB plane. This is a way of tuning with respect to mechanical, room or impedance constraints.

[0037] Therefore, the different strips of antenna device may be coplanar or not with respect to mechanical, room or impedance constraints. Somme small bended portions can be required for facilitating the connection of the pins of the antenna device to the ports of the PCB and to the metal plate.

[0038] The antenna device can be fabricated using common stamping process. Several ways are possible to interconnect the pins of the antenna device 1 to the PCB 2 and to the metal plate 3.

[0039] The feeding pin P1 and the ground pin P3 connected to the PCB 2 can be soldered, screwed or by using a kind of spring pin approach to avoid soldering process.

[0040] The ground pin P3 can be connected to the metal plate 3 by insertion into a slot made on top of the metal plate, by screwing or by using a spring system.

[0041] In FIGs.2 to 4, the radiating element (strips S2 and S4) of the antenna device does not overlap the ground plane of the PCB 2. It enables to reduce the directivity of the antenna and make the impedance matching easier to realize.

[0042] The antenna device 1 connected to the PCB 2 and the metal plate 3 as illustrated by FIGs.2 to 4 has been simulated using the HFSS™ 3D electromagnetic tool with the dimensions of the antenna device as defined in the previous Table 1. The simulation results are illustrated by FIGs.5 to 8:

FiG.5 demonstrates that the antenna device 1 is well matched in the Bluetooth band [2.4-2.5GHz] with a return loss level lower than -10dB in the worst case.
FIG.6 demonstrates that the peak gain is around 6-7dBi in the Bluetooth band.
FIG.7 demonstrates s that the efficiency is higher than 80% in the Bluetooth band.
FIG.8 shows that the antenna device radiates properly in the front side of the apparatus.

[0043] Although a preferred embodiment of the present invention has been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it should be understood that the present invention is not limited to the disclosed embodiment, but is capable of numerous rearrangements, modifications and substitutions without departing from the invention as set forth and defined by the following claims.

Claims

1. Antenna device (1) comprising a metal inverted-F antenna (1) to be mounted onto a printed circuit board (2), said metal inverted-F antenna being arranged for radiating radiofrequency signals in a predetermined frequency band and said printed circuit board including a feeding port and a ground port, **characterized in that** said metal inverted-F antenna (1) is further arranged for interconnecting the ground port of the printed circuit board (2) to a metal plate (3) separate from the printed circuit board.

2. Antenna device according to claim 1, wherein the metal inverted-F antenna (1) comprises a radiating element (10), a feeding element (11) and a ground element (12) arranged together to have an inverted-F shape and a connecting element (13) having a first end both connected to the ground element and the radiating element and a second end to be connected to the metal plate.

3. Antenna device according to claim 2, wherein the connecting element (13) comprises a first portion (S5) in line with the radiating element.

4. Antenna device according to claim 3, wherein the connecting element (13) comprises a second portion (S6) for connecting said first portion to the metal plate.

5. Antenna device according to claim 4, wherein the first and second portions (S5,S6) of the connecting element are perpendicular.

6. Antenna device according to any one of claims 2 to 5 wherein the ground element (12), the feeding element (11), the radiating element (10) and the connecting element (13) are coplanar.

7. Antenna device according to any one of claims 2 to 5 wherein the ground element (12), the feeding element (11), the radiating element (10) and the connecting element (13) are not coplanar.

8. Antenna device according to any one of claims 2 to 7 wherein the inverted-F antenna resonates at a resonant frequency in said predetermined frequency band and wherein the total length of the ground element (12) and the radiating element (10) is substantially equal to $\lambda/4$, where λ designates the wavelength associated to said resonant frequency.

9. Antenna device according to claim 8 wherein the length of the connecting element (13) is comprised between λ/8 and λ/4.

10. Apparatus comprising:

- a printed circuit board (2) comprising a ground port,
- a separate metal plate (3),
- a metal inverted-F antenna (1) according to any preceding claim mounted onto the printed circuit board.

11. Apparatus according to Claim 10, wherein the printed circuit board (2) comprises a ground plane and the inverted-F antenna comprises a radiating element, a feeding element and a ground element and wherein the radiating element does not overlap the ground plane of the printed circuit board.

12. Apparatus according to Claim 10 or 11, wherein the printed circuit board (2) and the metal plate (3) are not coplanar.

13. Apparatus according to Claim 12, wherein the printed circuit board and the metal plate are substantially perpendicular.

14. Apparatus according to any one of Claims 10 to 13, wherein the metal plate (3) is a grounding reference plate.

15. Apparatus according to any one of Claims 10 to 14, wherein the metal plate (3) is a heat spreading element.

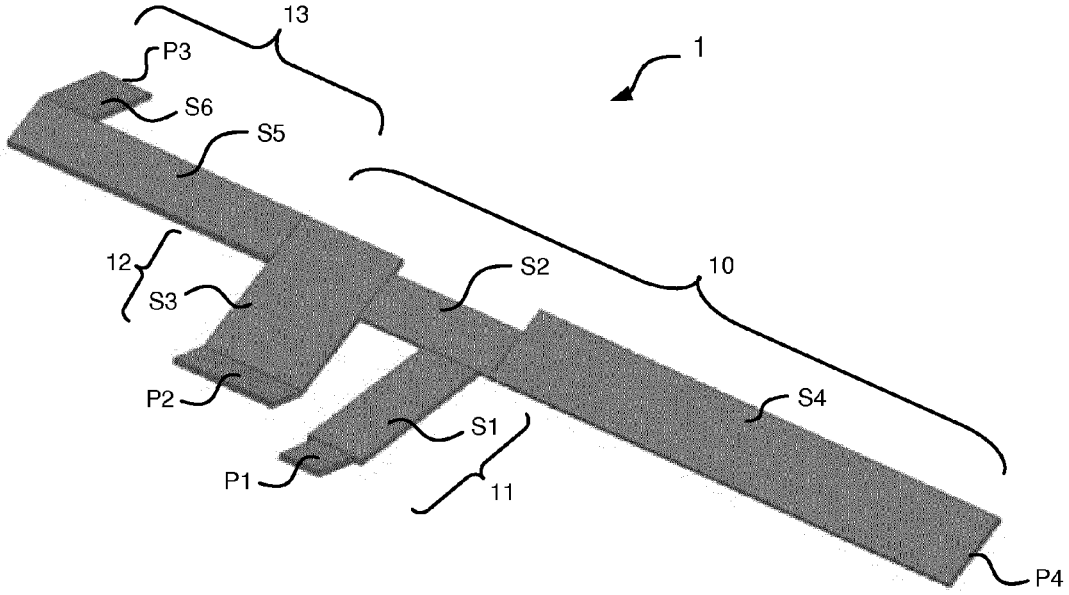

FIG.1

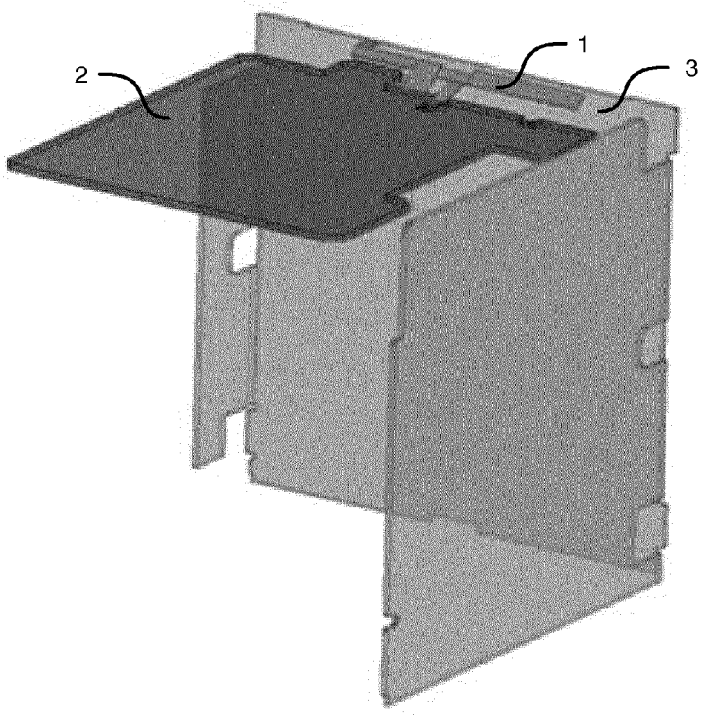

FIG.2

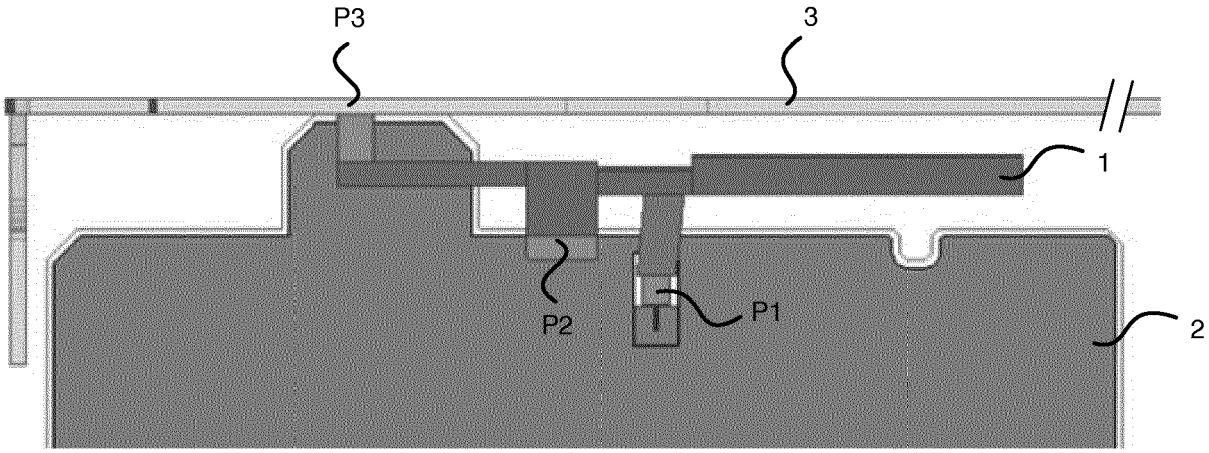

FIG.3

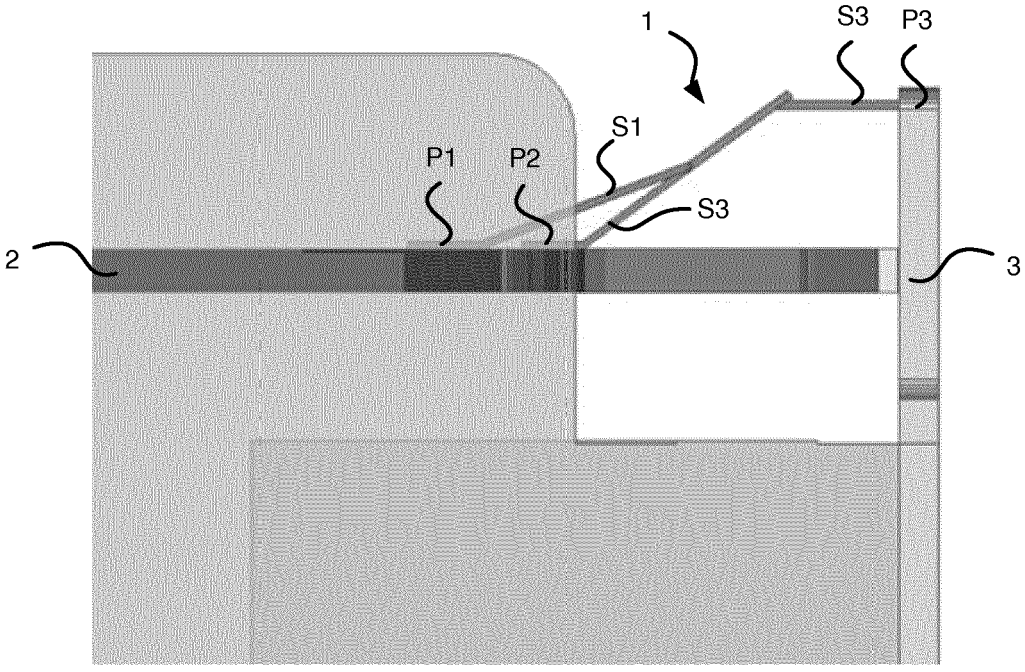

FIG.4

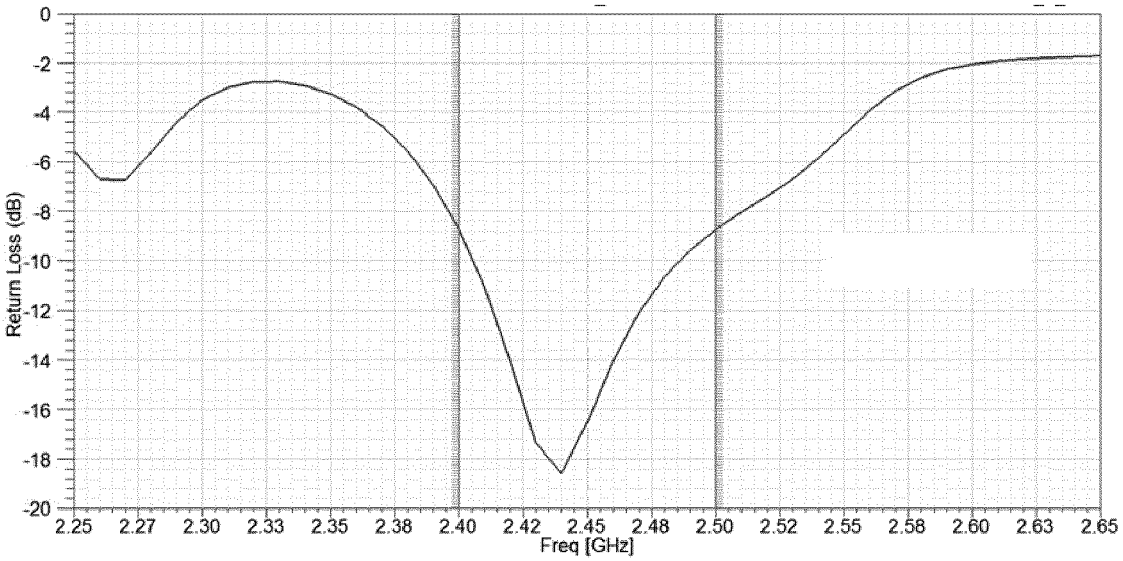
Return Loss (dB)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
2.25
2.27
2.30
2.33
2.35
2.38
2.40
2.42
2.45
2.48
2.50
2.52
2.55
2.58
2.60
2.63
2.65
Freq [GHz]

FIG.5

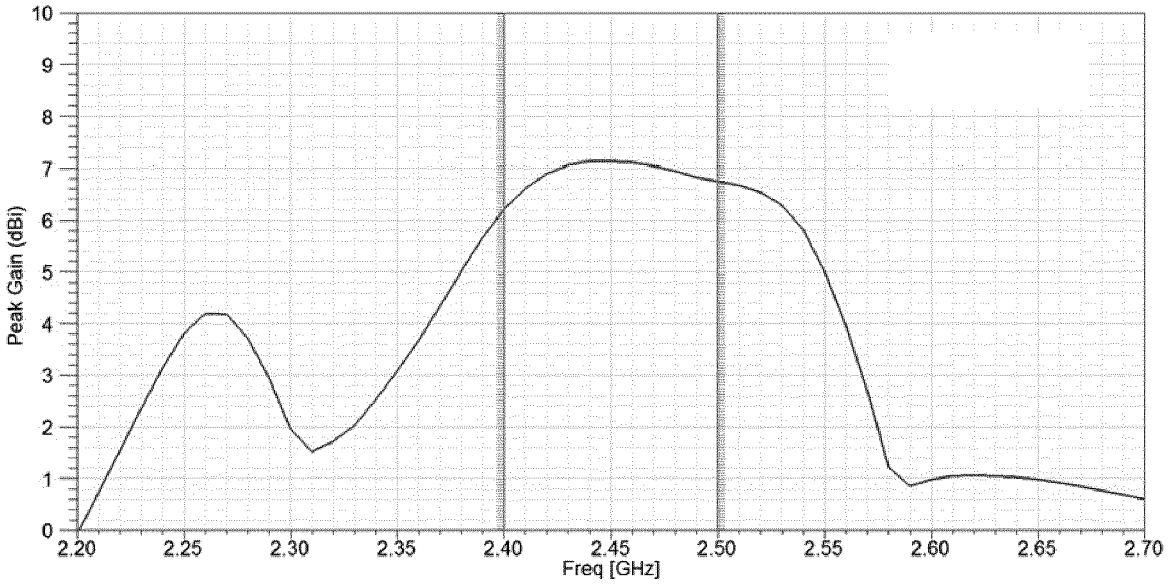
Peak Gain (dBi)
10
9
8
7
6
5
4
3
2
1
0
2.20
2.25
2.30
2.35
2.40
2.45
2.50
2.55
2.60
2.65
2.70
Freq [GHz]

FIG.6

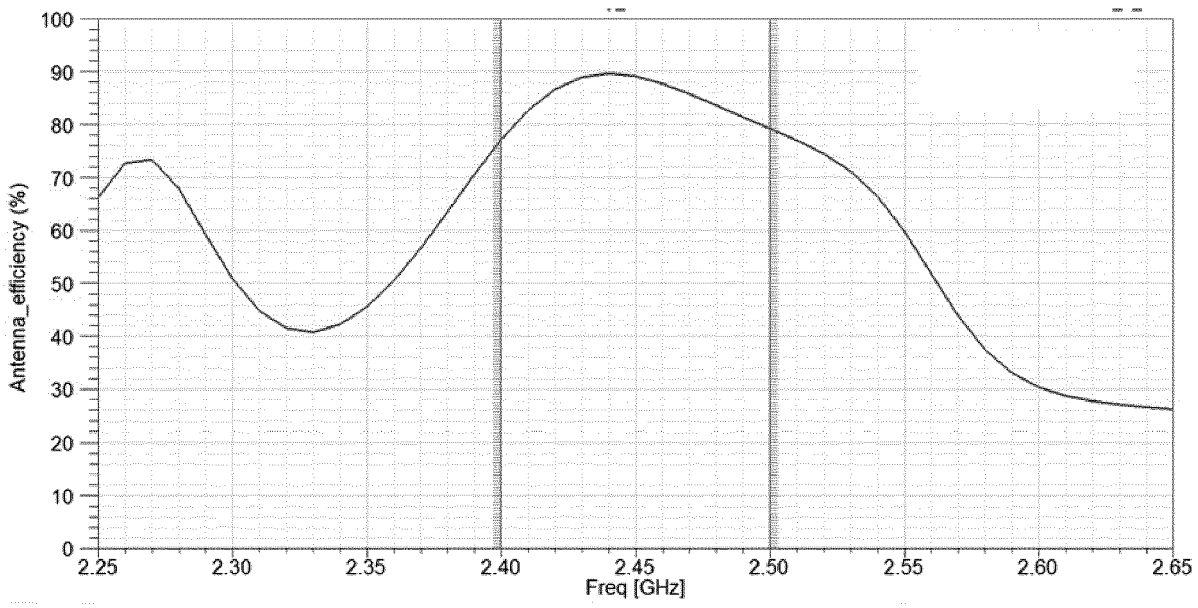
Antenna_efficiency (%)
100
90
80
70
60
50
40
30
20
10
0
2.25
2.30
2.35
2.40
2.45
2.50
2.55
2.60
2.65
Freq [GHz]

FIG.7

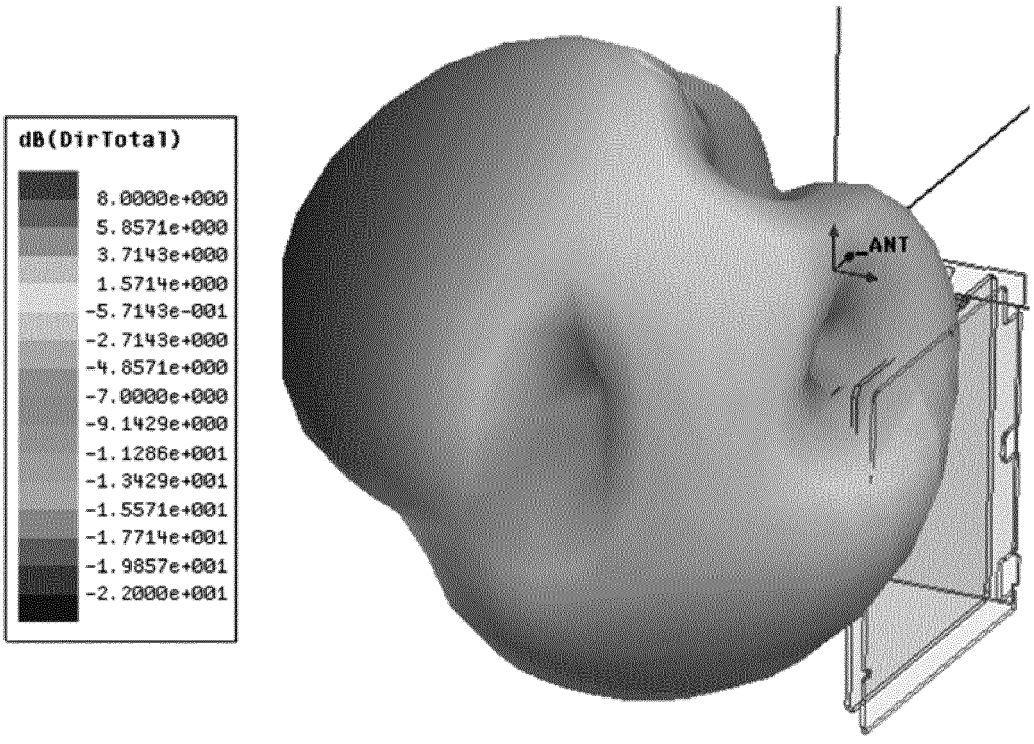
dB(DirTotal)
8.0000e+000
5.8571e+000
3.7143e+000
1.5714e+000
-5.7143e-001
-2.7143e+000
-4.8571e+000
-7.0000e+000
-9.1429e+000
-1.1286e+001
-1.3429e+001
-1.5571e+001
-1.7714e+001
-1.9857e+001
-2.2000e+001
ANT

FIG.8

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 16 30 5483

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	US 2012/064843 A1 (KIM CHANGIL [KR] ET AL) 15 March 2012 (2012-03-15) * figures 3,9 * * paragraphs [0076] - [0080] * -----	1-12,14, 15	INV. H01Q1/22 H01Q1/44 H01Q1/48 H01Q9/42
X	US 2016/072189 A1 (LO HINE TONG DOMINIQUE [FR] ET AL) 10 March 2016 (2016-03-10) * figures 1,2 * * paragraphs [0043] - [0049] * -----	1,2,7-15	
X	US 2012/176278 A1 (MERZ NICHOLAS G L [US] ET AL) 12 July 2012 (2012-07-12) * figure 2 * * paragraphs [0034] - [0036] * -----	1-6, 8-13,15	
X	US 2014/347226 A1 (IELLICI DEVIS [GB] ET AL) 27 November 2014 (2014-11-27) * figure 11 * * paragraph [0042] * -----	1,2,6, 8-11	
			TECHNICAL FIELDS SEARCHED (IPC) H01Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	27 September 2016	Niemeijer, Reint

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 16 30 5483

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

27-09-2016

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012064843 A1	15-03-2012	KR 20120026901 A	20-03-2012
		US 2012064843 A1	15-03-2012
US 2016072189 A1	10-03-2016	AU 2015215891 A1	24-03-2016
		CN 105406166 A	16-03-2016
		EP 2993731 A1	09-03-2016
		JP 2016059043 A	21-04-2016
		KR 20160029688 A	15-03-2016
		US 2016072189 A1	10-03-2016
US 2012176278 A1	12-07-2012	CN 102646862 A	22-08-2012
		EP 2664028 A2	20-11-2013
		KR 20130118919 A	30-10-2013
		TW 201234949 A	16-08-2012
		US 2012176278 A1	12-07-2012
		US 2012176279 A1	12-07-2012
		US 2014285386 A1	25-09-2014
		WO 2012096894 A2	19-07-2012
US 2014347226 A1	27-11-2014	CN 105474458 A	06-04-2016
		EP 3005472 A1	13-04-2016
		US 2014347226 A1	27-11-2014
		WO 2014190306 A1	27-11-2014

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82