



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**17.07.2019 Bulletin 2019/29**

(51) Int Cl.:  
**H01Q 13/16** (2006.01) **H01Q 9/40** (2006.01)  
**H01Q 1/38** (2006.01) **H01Q 1/24** (2006.01)  
**H01Q 1/48** (2006.01)

(21) Application number: **18305021.0**

(22) Date of filing: **12.01.2018**

(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 TN**

- **LOUZIR, Ali**  
**35576 Cesson-Sévigné Cedex (FR)**
- **LE NAOUR, Jean-Yves**  
**35576 Cesson-Sévigné Cedex (FR)**
- **PESIN, Anthony**  
**35576 Cesson-Sévigné Cedex (FR)**

(74) Representative: **Vidon Brevets & Stratégie**  
**16B, rue de Jouanet**  
**BP 90333**  
**35703 Rennes Cedex 7 (FR)**

(71) Applicant: **THOMSON LICENSING**  
**92130 Issy les Moulineaux (FR)**

(72) Inventors:  
• **HASKOU, Abdullah**  
**35576 Cesson-Sévigné Cedex (FR)**

(54) **HYBRID MONOPOLE SLOT ANTENNA**

(57) A novel antenna topology is proposed. The novel antenna topology is realized for example in a printed circuit board comprising at least a first and a second layer, the first layer being essentially non-conductive, the second layer being essentially conductive. A microstrip line fed conductive surface is etched in the first layer, and a non-conductive surface is etched in the second layer, one of either the conductive surface or the non-conductive surface surrounding the other, resulting in an interval between the conductive surface and the non-conductive surface in the plane of the printed circuit board. The novel antenna called hybrid monopole slot antenna preserves some interesting properties of the known annular slot antenna while improving the operating frequency range compared to the annular slot antenna.

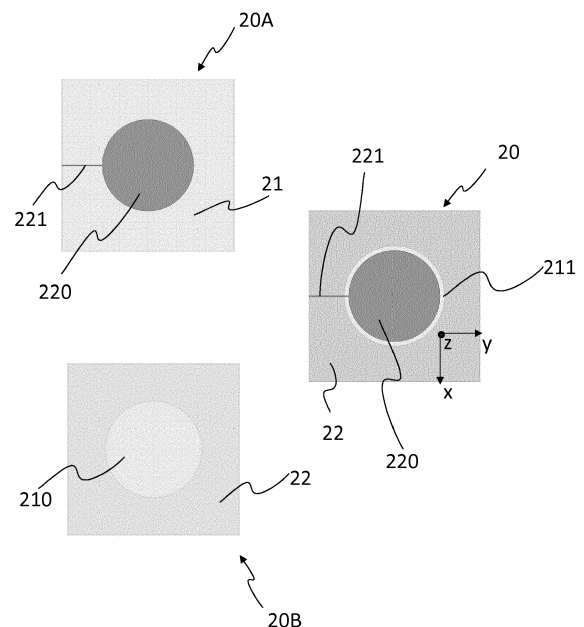


Figure 2

## Description

### 1. TECHNICAL FIELD

**[0001]** The present disclosure relates to an antenna adapted to be integrated in an apparatus for receiving a digital signal.

### 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. Annular slot antenna (ASA) are examples of known slot antenna wherein the slot is annular. The ASA is an interesting simple, low cost, easy to manufacture planar microstrip printed antenna with a compact shape factor and almost an omnidirectional radiation pattern when used with a finite ground plane. Despite of other interesting properties such as a natural decoupling between the antenna and the rest of the circuits thanks to the metalized surface, the operating frequency range of the ASA remains relatively limited though better than the patch antenna. A printed monopole antenna is another simple low cost known antenna presenting a wider operating frequency range than the ASA, but generally requiring a larger ground plane. Integrating a printed monopole antenna in a device also raises coupling issues with the rest of the circuits of the device. The present disclosure has been designed with the foregoing in mind.

### 3. SUMMARY

**[0003]** A novel antenna topology is proposed. The novel antenna topology is realized for example in a printed circuit board comprising at least a first and a second layer, the first layer being essentially non-conductive, the second layer being essentially conductive. A microstrip line fed conductive surface is etched in the first layer, and a non-conductive surface is etched in the second layer, one of either the conductive surface or the non-conductive surface surrounding the other, resulting in an interval between the conductive surface and the non-conductive surface in the plane of the printed circuit board. The novel antenna called hybrid monopole slot antenna preserves some interesting properties of the known annular slot antenna while improving the operating frequency range compared to the annular slot antenna.

**[0004]** To that end a printed circuit board antenna is disclosed. The printed circuit board antenna comprises a first layer and a second layer, the first layer comprising a conductive track connected to a conductive surface, the second layer comprising a non-conductive surface within a conductive area, wherein one of either the conductive surface or the non-conductive surface is sur-

rounding the other, the conductive surface and the non-conductive surface being centred in the plane of the printed circuit board antenna.

**[0005]** According to a variant, the conductive surface and the non-conductive surface have a same shape.

**[0006]** According to another variant, the shape is a disc.

**[0007]** According to another variant, the non-conductive surface and the conductive surface form an interval of a constant width in the plane of the printed circuit board.

**[0008]** According to another variant, the constant width is five millimetres.

**[0009]** According to another variant, the non-conductive surface and the conductive surface form an interval of variable width in the plane of the printed circuit board.

**[0010]** According to another variant, the first layer is a top layer of the printed circuit board antenna.

**[0011]** According to another variant, the first layer is one of any of internal conductive layers of the printed circuit board antenna.

**[0012]** According to another variant, the second layer is a bottom layer of the printed circuit board antenna.

**[0013]** According to another variant, the second layer is one of any of internal conductive layers of the printed circuit board antenna.

**[0014]** According to another variant, the non-conductive surface is surrounding the conductive surface in the plane of the printed circuit board antenna.

**[0015]** According to another variant, the printed circuit board comprises a third layer with a second non-conductive surface within a second conductive area, the second non-conductive surface being centred with the conductive surface and the non-conductive surface, the second non-conductive surface surrounding the conductive surface in the plane of the printed circuit board antenna.

**[0016]** According to another variant, the second non-conductive surface and the non-conductive surface have different sizes.

**[0017]** In a second aspect, a digital television receiver integrating an antenna according any of the above variant is also disclosed.

**[0018]** While not explicitly described, the present embodiments may be employed in any combination or sub-combination. For example, the present principles are not limited to the described variants, and any arrangement of variants and embodiments can be used. Moreover, the present principles are not limited to the described shape examples and any other type of shape for the conductive and non-conductive surfaces is compatible with the disclosed principles. The present principles are further not limited to the described numbers of layers of the printed circuit board antenna and are applicable to any arrangement of any number of layers of a printed circuit board antenna.

### 4. BRIEF DESCRIPTION OF THE DRAWINGS

**[0019]**

- **Figure 1** illustrates an annular slot antenna according to the prior art;
- **Figure 2** shows a hybrid monopole slot antenna according to a specific and non-limiting embodiment of the disclosed principles;
- **Figure 3A** and **3B** shows simulation results for a hybrid monopole slot antenna, according to a specific and non-limiting embodiment;
- **Figure 4** shows five examples of antenna according to five specific and non-limiting embodiments of the disclosed principles;
- **Figure 5** shows three further examples of antenna according to three specific and non-limiting embodiments of the disclosed principles;
- **Figure 6** shows four further examples of antenna according to four specific and non-limiting embodiments of the disclosed principles.

[0020] 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

[0021] 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 examples and conditions.

[0022] 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 block diagrams presented herein represent conceptual views of illustrative circuitry embodying the principles of the disclosure.

[0023] **Figure 1** illustrates an annular slot antenna according to the prior art. **Figure 1** shows three schematic views of the ASA 10. The two left hand views 10A, 10B represent respectively a top side 10A and a bottom side 10B of the ASA 10. The right-hand view represents the elements present both at the top and bottom sides of the ASA 10. The bottom side of the ASA 10 is a conductive ground plane 12 comprising an annular slot 110. The top side of the ASA is a non-conductive substrate 11 comprising a metallized microstrip line 120. When the metallized microstrip line 120 is driven by a signal at a given frequency, the annular slot 110 radiates electronic waves in a way similar to a dipole antenna. The slot nature of

the ASA presents also some interesting features, such as, the easy integration of active devices in the slot for radiation pattern or frequency reconfiguration of the antenna. Another advantage of a slot antenna such as the ASA is the natural decoupling between the antenna and the rest of the circuits which could be realized either on the space available backside of the ground plane where the radiating slot is etched or on a separate printed circuit board (PCB) which is shielded by the slot ground plane. This makes the ASA antenna a good candidate for being integrated in electronic devices such as communication devices.

[0024] The term "slot" is used throughout the disclosed principles to refer to a non-conductive area etched in a conductive area within a same layer of for example a PCB. The slot represents a hole cut out of for example a metal surface.

[0025] **Figure 2** shows a Hybrid Monopole Slot (HMS) antenna according to a specific and non-limiting embodiment of the disclosed principles. According to the specific and non-limiting embodiment, the HMS antenna 20 is a printed circuit board antenna comprising a first layer 20A and a second layer 20B separated by a non-conductive substrate. The first layer 20A comprises a conductive track 221 feeding a conductive surface 220. The first layer is for example made of a non-conductive substrate 21, on which a conductive track such as a microstrip line 221 and a conductive surface 220 are printed, the conductive track 221 being connected to the conductive surface 220. In another example, the conductive track and the conductive surface are etched on the PCB. In yet another example, the conductive track and the conductive surface are stuck on the PCB. The conductive surface is for example a metallized surface of any shape, for example a disc shape as illustrated. **Figure 2** shows the microstrip line and the conductive surface as the only conductive elements printed on the non-conductive substrate. However, any first layer comprising other conductive elements such as conductive tracks between components or circuits (not represented in **Figure 2**) are also compatible with the disclosed principles. The second layer 20B comprises a non-conductive surface 210 embedded in a conductive area. The conductive area at least surrounds the non-conductive surface. The non-conductive surface 210 is for example etched from a fully conductive layer 22. In other words, the second layer 20B is fully conductive except the surface 210 being etched in the conductive layer 22. Partially conductive layers, for example, comprising areas of conductive surfaces (wherein one of them surrounds the non-conductive surface), although not being fully conductive are also compatible with the disclosed principles. The second layer needs only to be sufficiently conductive to serve for example as a ground layer in a PCB.

[0026] According to the specific and non-limiting embodiment of the disclosed principles, one of either the conductive surface 220 or the non-conductive surface 210 is surrounding the other, the conductive surface 220

and the non-conductive surface 210 being centred in the plane of the printed circuit board antenna 20. An interval 211 between the non-conductive surface 210 and the conductive surface 220 results from one of either the conductive surface 220 or the non-conductive surface 210 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. In other words, when looking at projections of both surfaces in the plane of the PCB, one projected surface is completely included in the other. The interval between the non-conductive surface 210 and the conductive surface 220 of different layers of the PCB antenna behaves as a slot antenna by radiating electromagnetic waves. The interval although behaving as a slot, differs from a slot as an interval is a hole between conductive surfaces of different layers while a slot is a hole within a conductive surface of same layer.

**[0027]** According to a first variant, (represented in **Figure 2**), the non-conductive surface 210 is surrounding the conductive surface 220 in the plane of the PCB, forming an interval 211 between the conductive 220 and the non-conductive 210 surfaces. Said differently, a projection of the conductive surface 220 in the plane of the PCB is included in the projection of the non-conductive surface 210 in the same plane of the PCB. According to a second variant (not represented in **Figure 2**), the conductive surface 220 is surrounding the non-conductive surface 210 in the plane of the PCB, also forming an interval 211 between the conductive 220 and the non-conductive 210 surfaces. The interval between 211 between the conductive 220 and the non-conductive 210 surfaces of the HMS antenna behaves as a slot in a slot antenna, by radiating electromagnetic waves when the conductive track is driven by a signal.

**[0028]** According to this specific and non-limiting embodiment, the conductive surface 220 and the non-conductive surface 210 have a same shape, being a disc (as represented in **Figure 2**). Other shapes (as represented further in **Figures 4** and **6**) are compatible with the disclosed principles. Moreover, a HMS antenna with a conductive surface and a non-conductive surface of different shapes, wherein one of the surface is surrounding the other, is also compatible the disclosed principles.

**[0029]** In a specific variant, the first layer 20A is the top layer of the printed circuit board antenna, and/or the second layer 20B is the bottom layer of the printed circuit board antenna. The top and bottom layers are the two external layers of the PCB, being respectively the front and the back side of the PCB. The disclosed principles are not limited to PCBs with the first and the second layers 20A, 20B being external layers. Any PCB wherein one or both of the first and the second layers are internal layers of the PCB is also compatible with the disclosed principles.

**[0030]** According to the specific variant, the HMS antenna 20 is composed of a microstrip line fed circular conductive disc 220 etched on one side of a PCB and a

circular non-conductive disc slot 210 realized on the other side (the ground side) of the substrate. The sizing of the HMS antenna is so that the non-conductive circular disc slot 210 and the conductive circular disc 220 are aligned in the (x,y) plane, while the diameter of the first is 10 mm larger than the diameter of the second and so that the interval 211 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 ASA.

**[0031]** **Figure 3A** and **3B** show simulation results for a HMS antenna designed for a central frequency around 600MHz, according to a specific and non-limiting embodiment.

**[0032]** The antenna is printed on a commonly used 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 300mm by 300mm. The diameter of the disc (conductive surface) is 160 mm. The width of the interval between both discs is constant and about 5 mm. **Figure 3A** shows proposed antenna input reflection coefficient magnitude in dB compared from one side, to an "equivalent" regular ASA (with the exact same dimensions and excited through microstrip to slot line quarter-wave transition) and, on the other side a monopole (with the same dimensions and ground-disc distance of 5mm). As it can be noticed, the HMS antenna has a performance similar to an ASA however with a wider bandwidth. This can also be seen from the radiation efficiency given in **Figure 3B**, showing a comparison of the radiation efficiency over the frequency band for the HMS, the ASA and the monopole antenna. Although the Monopole antenna shows a wider radiation efficiency than the ASA or the HMS, it does not provide the same advantages as the ASA. The HMS antenna is advantageous compared to the existing antenna because it preserves the advantages of the ASA (omnidirectional pattern, natural decoupling of the antenna with the rest of the circuits) and provides an increased radiation efficiency compared to the ASA. Increasing the radiation efficiency in the lower frequencies (around 200 MHz) is particularly interesting as it allows to reduce the size of the antenna (for a same level of performance) facilitating its integration in a device. As the HMS antenna provides the same omnidirectional radiation pattern as the ASA, the same natural decoupling properties with an increased radiation efficiency in the lower frequencies, the HMS antenna is a very good omnidirectional antenna solution for being integrated in a device.

**[0033]** 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. The PCB antenna is for example a square of 300mm by 300mm, the diameter of the conductive disc (conductive surface) is 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 HMS antenna are adapted for

an indoor TV reception without requiring any external or outdoor antenna. The integration a HMS 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 HMS 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 600/5000). According to this specific and non-limiting embodiment, a HMS 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. Such an antenna device can be integrated in wireless devices such a cell phones, Wi-Fi cards or Wi-Fi access points. Any HMS design with dimensions adapted to a targeted frequency is compatible with the disclosed principles.

**[0034]** Figure 4 shows five examples of HMS antenna 4A, 4B, 4C, 4D, 4E, according to five specific and non-limiting embodiments of the disclosed principles. All the HMS examples illustrated at Figure 4 represent conductive and non-conductive surfaces of a same shape, wherein the shape is a triangle 4A, a square 4B, a polygon 4C, an ellipse 4D or a ripple 4E.

**[0035]** Figure 5 shows three examples of HMS antenna 5A, 5B, 5C according to three specific and non-limiting embodiments of the disclosed principles. Figure 5 shows two HMS antenna 5A, 5B wherein the PCB is a square. Figure 5 shows a HMS antenna 5C wherein the PCB is a polygon. Figure 5 also illustrates different positions and length of the conductive track connected to the conductive surface.

**[0036]** Figure 6 shows four examples of HMS antenna 6A, 6B, 6C, 6D according to four specific and non-limiting embodiments of the disclosed principles. While Figures 2, 4 and 5 show HMS antenna with an interval between the conductive and the non-conductive surfaces of a constant width, the HMS antenna 6A, 6B, 6C, 6D comprise an interval 211 between the conductive and the non-conductive surfaces of variable width in the plane of the HMS antenna. Moreover, the HMS antenna 6C and 6D comprise conductive surfaces and non-conductive surfaces of different shapes. Adjusting the shape, and/or the width of the interval allow for example to further finetune some other characteristics of the antenna such as for example and without limitation the frequency adaptation, the radiating pattern, frequency band efficiency.

**[0037]** According to a non-illustrated specific and non-limiting embodiment, the PCB comprises a third layer with a second non-conductive surface embedded in a second conductive area, the second non-conductive sur-

face being centred with the surface and the non-conductive surface, the second non-conductive surface surrounding at least one of the conductive and the non-conductive surfaces in the plane of the printed circuit board antenna. In a first variant the second non-conductive surface surrounds only one of either the conductive or the non-conductive surfaces in the plane of the printed circuit board antenna. In that first variant, the surface being surrounded by the second non-conductive surface is the smaller surface. In a second variant the second non-conductive surface surrounds only both the conductive or the non-conductive surfaces in the plane of the printed circuit board antenna. According to that second variant, the second non-conductive surface and the non-conductive surface have different sizes. Adding such additional layers comprising further non-conductive surfaces as described above allows to further expand the frequency band of the antenna by multiplying resonators to neighbouring frequencies.

## Claims

1. A printed circuit board antenna (20, 4A, 4B, 4C, 4D, 4E, 5A, 5B, 5C, 6A, 6B, 6C, 6D) comprising a first layer (20A) and a second layer (20B), the first layer (20A) comprising a conductive track (221) connected to a conductive surface (220), the second layer (20B) comprising a non-conductive surface (210) within a conductive area (22), wherein one of either the conductive surface (220) or the non-conductive surface (210) is surrounding the other, the conductive surface (220) and the non-conductive surface (210) being centred in the plane of the printed circuit board antenna (20).
2. The antenna according to claim 1, wherein the conductive surface (220) and the non-conductive surface (210) have a same shape.
3. The antenna according to claim 2, wherein the shape is a disc.
4. The antenna according to claim 2, wherein the shape belongs to a set comprising a, triangle, a square, a rectangle, an ellipse, a polygon, a ripple.
5. The antenna according to any of claims 1 to 4, wherein the non-conductive surface (210) and the conductive surface (220) form an interval (211) of a constant width in the plane of the printed circuit board.
6. The antenna according to claim 5 wherein the constant width is five millimetres.
7. The antenna according to claim 1, wherein the non-conductive surface (210) and the conductive surface (220) form an interval (211) of variable width in the

plane of the printed circuit board.

8. The antenna according to any of claims 1 to 7, wherein the first layer is a top layer of the printed circuit board antenna. 5
9. The antenna according to any of claims 1 to 7, wherein the first layer is one of any of internal conductive layers of the printed circuit board antenna. 10
10. The antenna according to any of claims 1 to 9, wherein the second layer is a bottom layer of the printed circuit board antenna.
11. The antenna according to any of claims 1 to 9, wherein the second layer is one of any of internal conductive layers of the printed circuit board antenna. 15
12. The antenna according to any of claims 1 to 11, wherein the non-conductive surface is surrounding the conductive surface in the plane of the printed circuit board antenna. 20
13. The antenna according to any of claims 1 to 12 wherein the printed circuit board comprises a third layer with a second non-conductive surface within a second conductive area, the second non-conductive surface being centred with the conductive surface and the non-conductive surface, the second non-conductive surface surrounding the conductive surface in the plane of the printed circuit board antenna. 25 30
14. The antenna according to claim 13 wherein the second non-conductive surface and the non-conductive surface have different sizes. 35
15. A digital television receiver integrating an antenna according to any of claims 1 to 14.

40

45

50

55

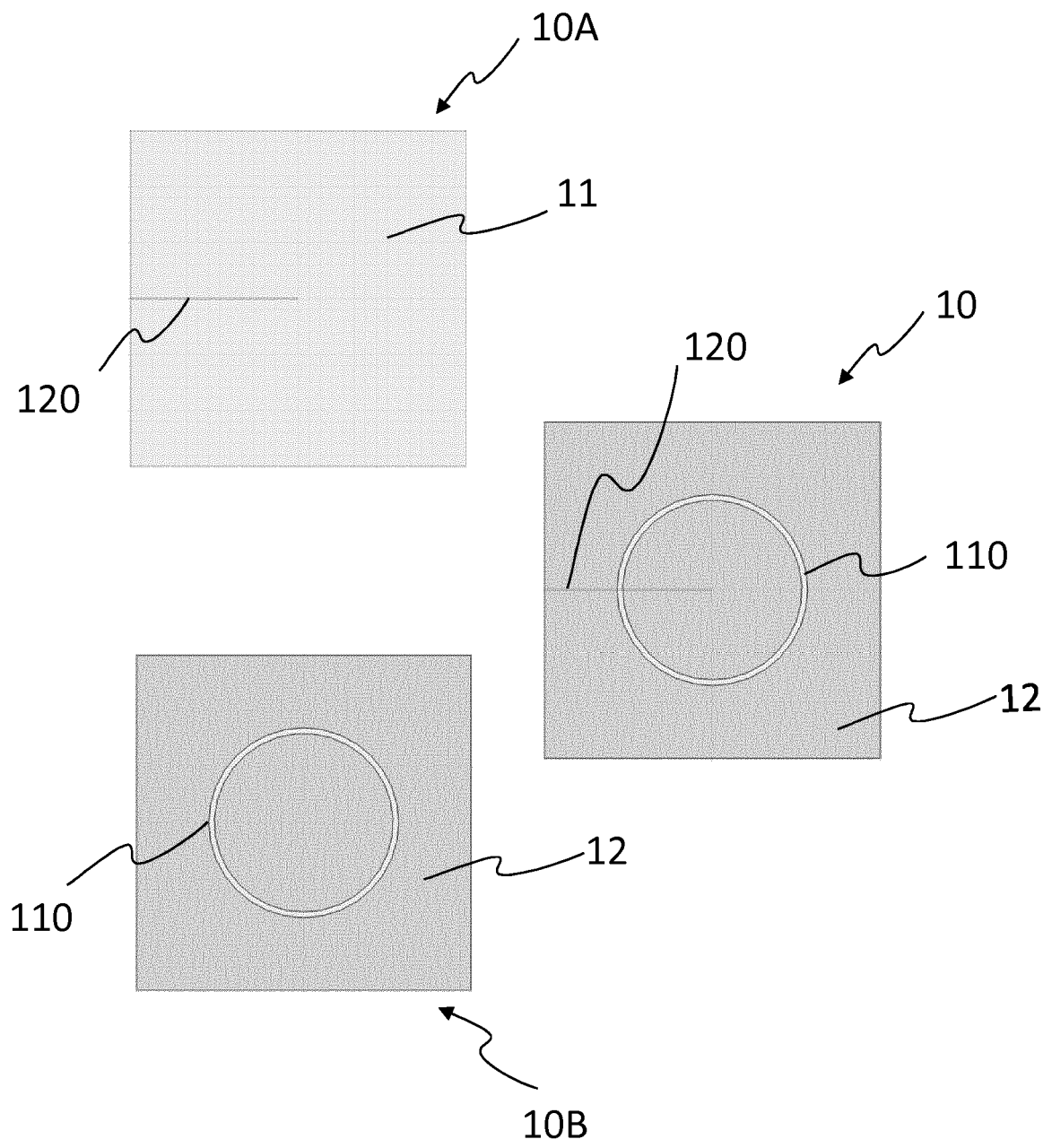


Figure 1

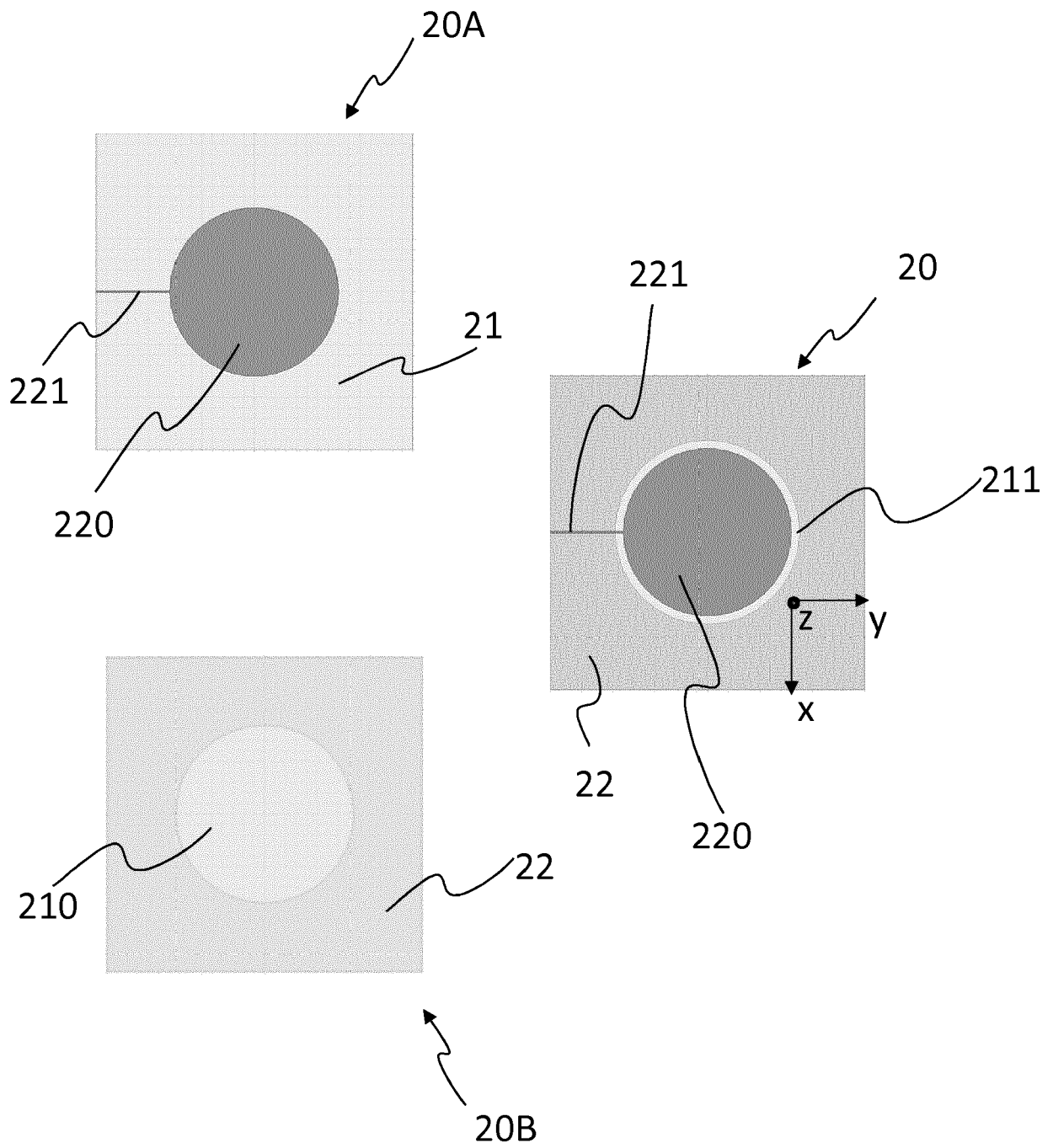


Figure 2

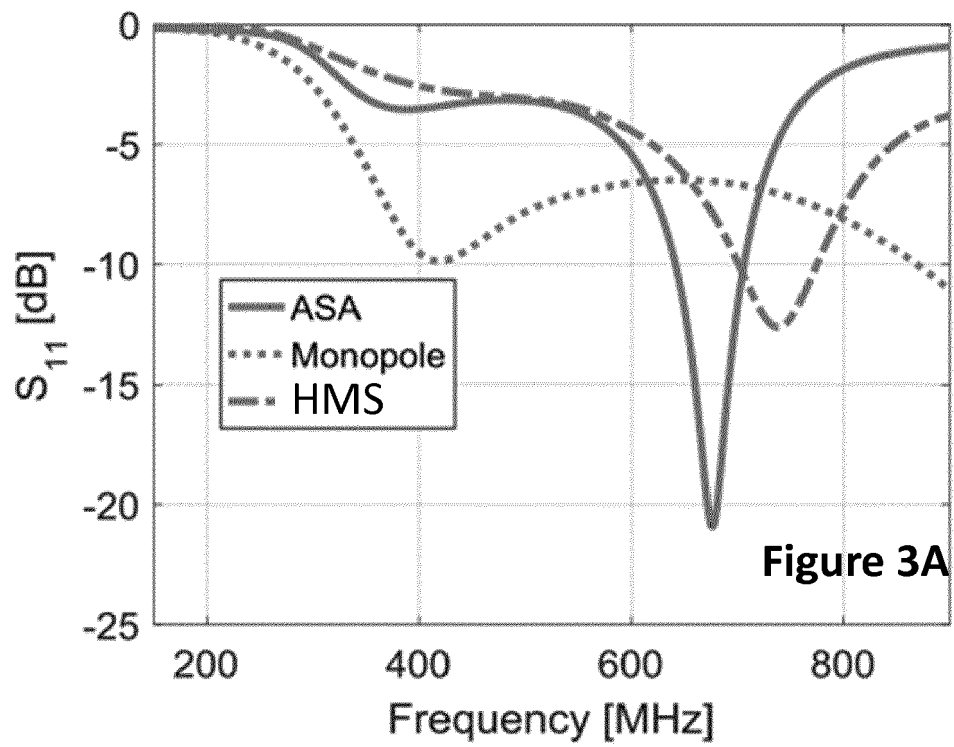


Figure 3A

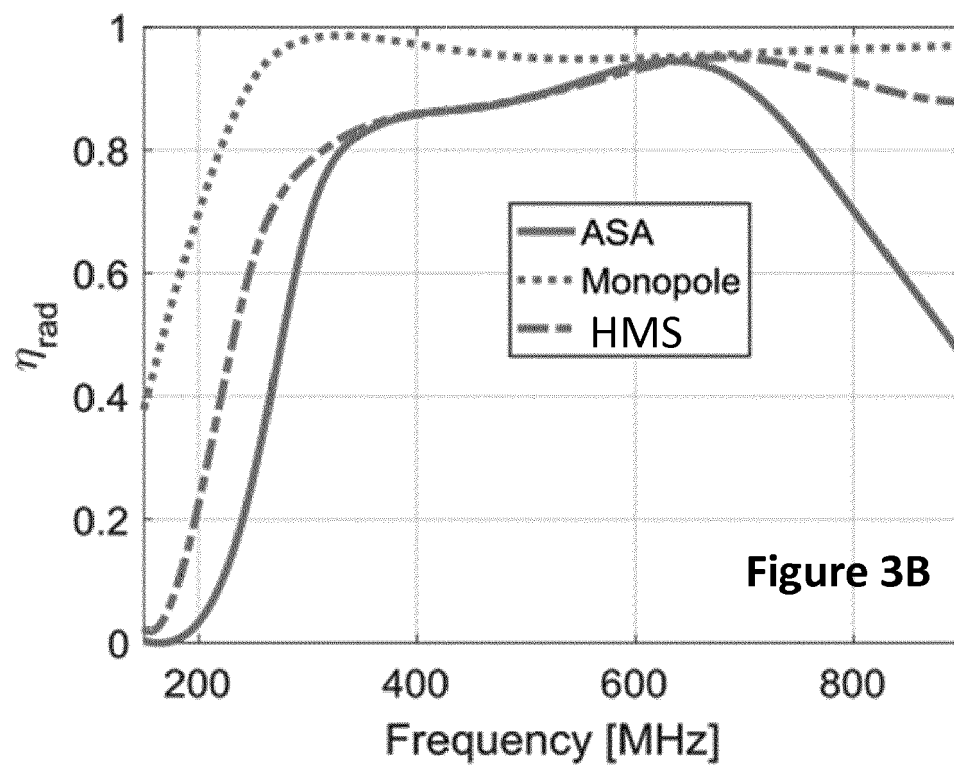


Figure 3B

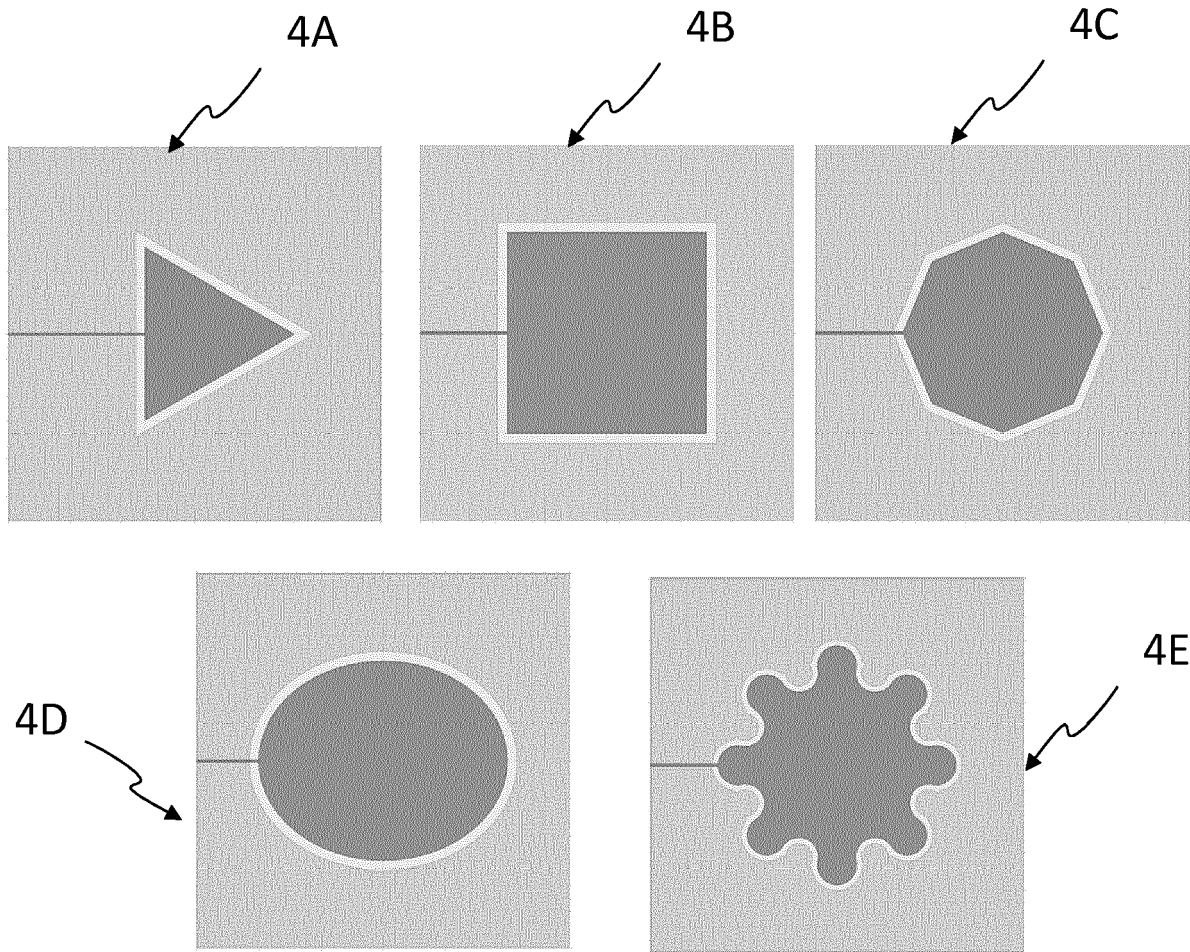


Figure 4

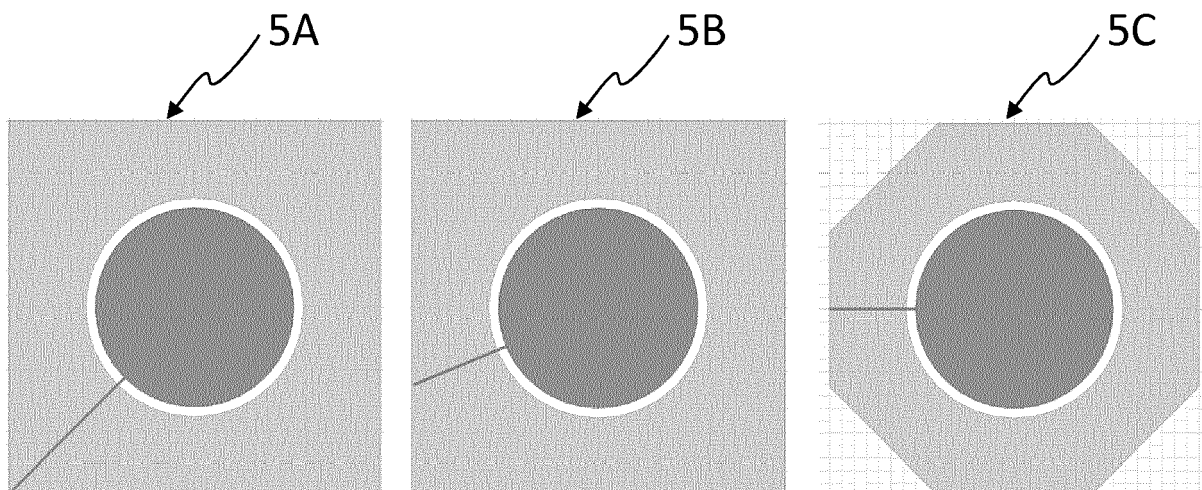


Figure 5

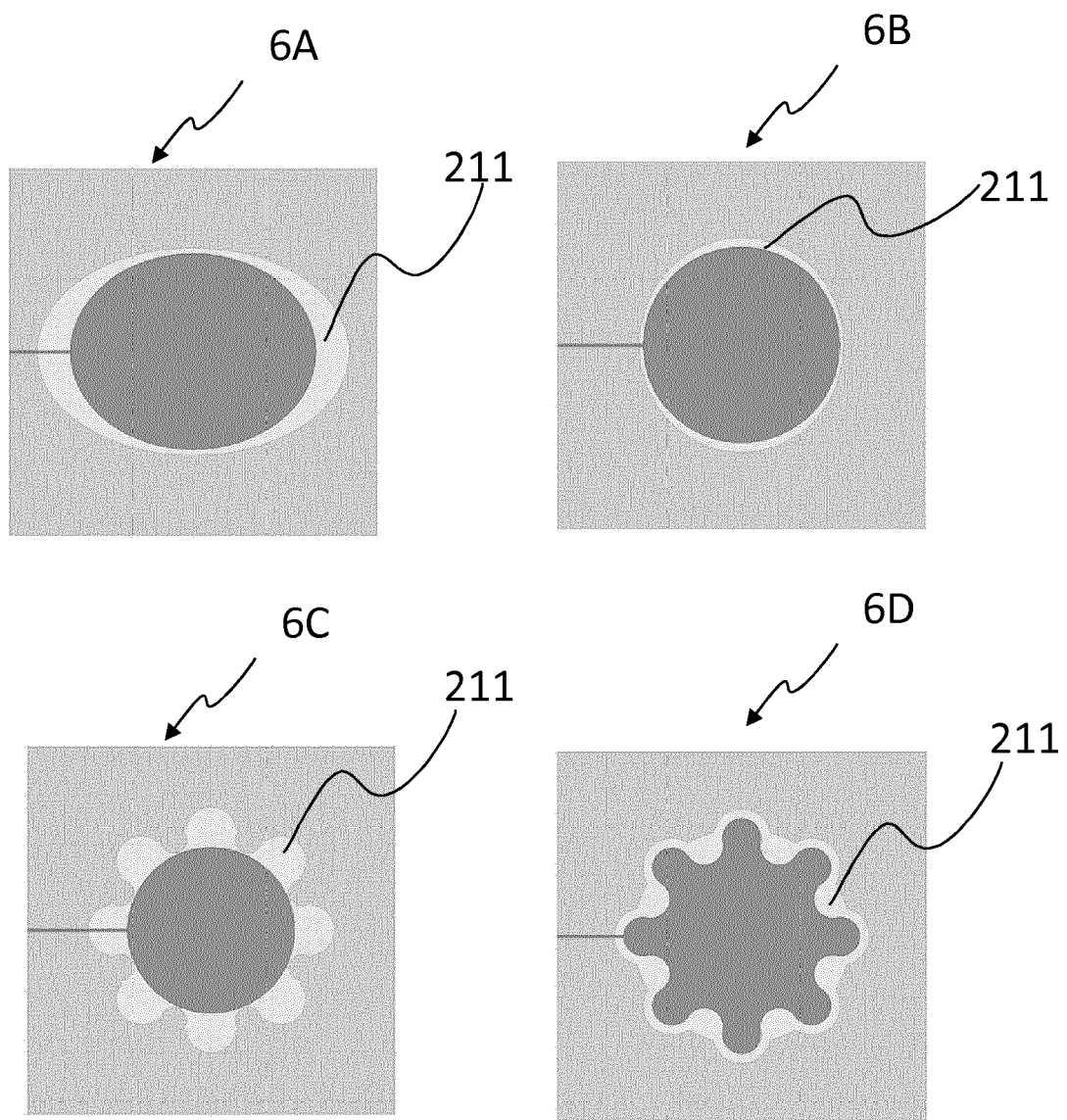


Figure 6



## EUROPEAN SEARCH REPORT

Application Number  
EP 18 30 5021

5

10

15

20

25

30

35

40

45

50

55

| 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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | JP S51 101447 A (TOKYO SHIBAURA ELECTRIC CO; MATSUMOTO MASAKADO)<br>7 September 1976 (1976-09-07)<br>* page 2 - page 3; figures 1,7 *                                                                                                                                                                                                                                                                                   | 1-12,15                                          | INV.<br>H01Q13/16<br>H01Q9/40<br>H01Q1/38<br>H01Q1/24<br>H01Q1/48 |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | JP 2002 252520 A (ASAHI GLASS CO LTD)<br>6 September 2002 (2002-09-06)<br>* abstract; figures 1,2 *                                                                                                                                                                                                                                                                                                                     | 1-15                                             |                                                                   |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | PALAZZI VALENTINA ET AL: "Scavenging for Energy: A Rectenna Design for Wireless Energy Harvesting in UHF Mobile Telephony Bands",<br>IEEE MICROWAVE MAGAZINE, IEEE SERVICE CENTER, PISCATAWAY, NJ, US,<br>vol. 18, no. 1,<br>12 December 2016 (2016-12-12), pages 91-99, XP011636501,<br>ISSN: 1527-3342, DOI:<br>10.1109/MMM.2016.2616189<br>[retrieved on 2016-12-09]<br>* Section "Antenna Design";<br>figures 1,2 * | 1-15                                             |                                                                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                  | TECHNICAL FIELDS SEARCHED (IPC)                                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                  | H01Q                                                              |
| The present search report has been drawn up for all claims                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                  |                                                                   |
| Place of search<br>The Hague                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                         | Date of completion of the search<br>12 June 2018 | Examiner<br>Hüschelrath, Jens                                     |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document<br>T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : 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 18 30 5021

5

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.

12-06-2018

10

| Patent document<br>cited in search report |   | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
|-------------------------------------------|---|---------------------|----------------------------|---------------------|
| JP S51101447                              | A | 07-09-1976          | NONE                       |                     |
| -----                                     |   |                     |                            |                     |
| JP 2002252520                             | A | 06-09-2002          | NONE                       |                     |
| -----                                     |   |                     |                            |                     |

15

20

25

30

35

40

45

50

55

EPO FORM P0459

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