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(54) **MULTIBAND PATCH ANTENNA**

(57) A multiband patch antenna (10) comprises at least two different patch fields (16; 24, 26, 28) being of at least two different patch field types (A, B, C), wherein at least two of the patch fields (16; 24, 26, 28) have overlapping areas (O). The feedpoint (18) is positioned in a way that, each of the at least two patch fields (16; 24, 26, 28) emits electromagnetic radiation having the frequency

of the predefined resonance frequency (f_1 , f_2 , f_3) of the respective patch field (16; 24, 26, 28) and/or a combination of two or more of the at least two patch field (16; 24, 26, 28) emits electromagnetic radiation having a frequency of one of the resonance frequencies (f_1 , f_2 , f_3) or a further frequency.

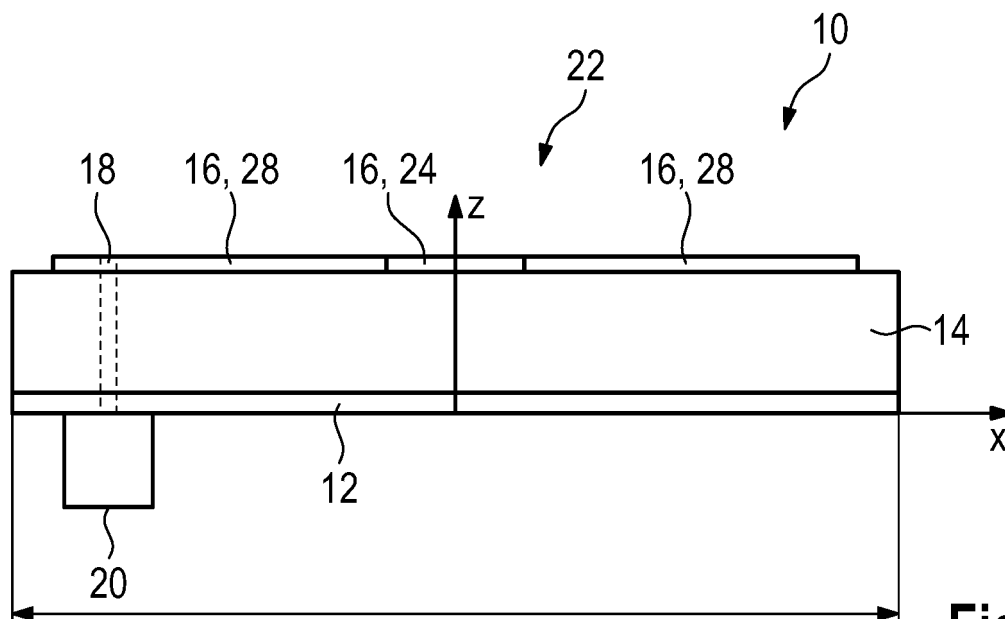


Fig. 1

Description

[0001] The invention is concerned with a multiband patch antenna.

[0002] Multiband patch antennas are known and are used for wireless communication devices with no external antennas, i.e. devices in which the antenna is within a housing. However, multiband patch antennas are weakly directional meaning that the emitted electromagnetic radiation is also radiated deeper into the housing of the device. This leads to adverse effects, like interference with the electronic components within the housing.

[0003] Multiband patch antennas with highly directional radiation characteristics that do not interfere with the electronic components are usually very thick and thus occupy valuable space within the housing.

[0004] It is the purpose of the invention to provide a thin multiband patch antenna with a highly directional radiation characteristic.

[0005] For this purpose, a multiband patch antenna, in particular a multiband printed circuit board (PCB) antenna is provided, comprising a ground plane, at least one feedpoint, and at least two different patch fields being of at least two different patch field types, wherein each patch field type is designed for a different predefined resonance frequency. At least two of the patch fields have overlapping areas, and the feedpoint is positioned in a way that, when a feed signal is fed to the feedpoint, each of the at least two patch fields emits electromagnetic radiation having the frequency of the predefined resonance frequency of the respective patch field and/or a combination of two or more of the at least two patch field emits electromagnetic radiation having a frequency of one of the resonance frequencies or a further frequency.

[0006] By overlapping several patch fields with different resonance frequencies, it is possible to achieve a highly directional radiation characteristic of the multiband patch antenna 10.

[0007] Of course, the patch fields emit electromagnetic radiation in conjunction with the ground plane. However, for the sake of simplicity, it is referred to that the patch fields emit the electromagnetic radiation.

[0008] Preferably, the at least two patch fields are free of cutouts and/or define a continuous antenna area so that the fabrication of the antenna is simplified.

[0009] The at least two patch fields may have a rectangular geometry and/or the patch fields of the at least two patch field types may have different sizes. This way, the resonance frequency of the patch fields may be tuned easily.

[0010] To this end, the vertical length and/or the horizontal length of the patch fields may depend on the resonance frequency of the respective patch field type.

[0011] In an embodiment of the invention, for at least one of the at least two patch field types two patch fields are provided in order to improve radiation performance.

[0012] In an aspect, the multiband patch antenna is symmetrical with respect to an axis, particularly wherein

the axis extend through the geometric center of the patch fields. This way, the radiation characteristics may be improved further.

[0013] The geometric center of the patch fields is, in particular, the geometric center of the antenna area. The antenna area is thus also symmetrical.

[0014] For an improved directional radiation characteristics, the ground plane is quadratic and/or has a cutout for each of the at least one feedpoint only, in particular that the ground plane is free of cutouts.

[0015] In a further embodiment, the multiband patch antenna comprises a support layer being provided between the at least one patch field and the ground plane, wherein the support layer has a via for each of the at least one feedpoint only, in particular that the support layer is free of vias. This design simplifies fabrication of the multiband patch antenna even further.

[0016] For reliable feeding, the at least one feedpoint is provided as a coaxial feed or an insert feed.

[0017] In an embodiment of the invention, a first patch field of a first patch field type with a first resonance frequency, at least one second patch field of a second patch field type with a second resonance frequency and at least one third patch field of a third patch field type with a third resonance frequency are provided, wherein the first patch field partly overlaps with the at least one second patch field and the at least one third patch field, particularly wherein the at least one second patch field and the at least one third patch field do not overlap. This way, the radiation characteristic of each of the resonance frequencies is highly directional.

[0018] For a reliably feed the multiband patch antenna, the at least one feedpoint may be located at the at least one second patch field and/or at the least one third patch field.

[0019] In order to improve the radiation characteristics of electromagnetic radiation with the first resonance frequency, the at least one second patch field and at the least one third patch field may be spaced apart by a vertical distance, wherein the sum of the vertical distance, the vertical length of the at least one second patch field and the vertical length of the at least one third patch field is about equal to the horizontal length of the first patch field.

[0020] In another embodiment, exactly one first patch field, exactly two second patch fields and exactly two third patch fields are provided, particularly wherein the two second and two third patch fields each overlap with one of the corners of the first patch field.

[0021] To improve the radiation characteristics even further, the two third patch fields may be spaced apart by a third horizontal distance, wherein the third horizontal distance is about equal to the horizontal length of the third patch fields and/or the two second patch fields may be spaced apart by a second horizontal distance, wherein either the second horizontal distance is about equal to half of the horizontal length of the second patch fields or the second horizontal distance is about equal to the third

horizontal distance.

[0022] For a symmetrical radiation characteristic, the geometric center of the first patch field may be the geometric center of the patch fields, in particular the geometric center of the antenna area.

[0023] Further features and advantages will be apparent from the following description as well as the accompanying drawings, to which reference is made. In the drawings:

- Figure 1 shows a side view of a multiband patch antenna according to the invention,
- Figure 2 shows a top view of the multiband patch antenna according to Figure 1, and
- Figure 3 shows a schematic drawing of the antenna area of the multiband patch antenna according to Figure 1.

[0024] Figures 1 and 2 show a multiband patch antenna 10, in the shown embodiment a multiband printed circuit board (PCB) antenna.

[0025] The multiband patch antenna 10 may be used in devices requiring wireless communication, like routers, access points, weather stations, and mobile devices, like mobile phones, tablets, laptop computers, Internet of Things (IoT) devices and any other device with a communication interface.

[0026] The multiband patch antenna 10 is for example used for Wi-Fi communication, for example for MU-MIMO WLAN access points.

[0027] In such devices, the multiband patch antenna 10 may be one of a plurality of similar or identical antennas in an antenna array.

[0028] The multiband patch antenna 10 comprises a ground plane 12, a support layer 14, a plurality of patch fields 16 and a feedpoint 18.

[0029] The support layer 14 may be a known substrate for printed circuit boards, like a wafer or FR-4.

[0030] The ground plane 12 and the patch field 16 are located on opposite sides of the support layer 14.

[0031] The patch fields 16 are created of a conductive material directly onto the support layer 14 and all of them have the same thickness.

[0032] The ground plane 12 is, for example, quadratic. The sides of the quadratic ground plane 12 may be 50 mm long. The ground plane 12 may be made of a conductive layer created directly on the support layer 14.

[0033] The ground plane 12 extends in the plane of the support layer 14 further than the patch fields 16.

[0034] The feedpoint 18 is located in one of the patch fields 16 and is connected to a signal source 20 located on the side of the ground plane 12 facing away from the support layer 14.

[0035] An electrical connection between the signal source 20 and the feedpoint 18 is achieved through the support layer 14 and the ground plane 12. For this pur-

pose, the ground plane 12 and the support layer 14 have a cutout and a via, respectively. Apart from the cutout and the via for the feedpoint 18, the ground plane 12 and the support layer 14 are free of cutouts and vias, respectively.

[0036] As can be seen in Figure 2, which shows the multiband patch antenna 10 in a top view, the multiband patch antenna 10 comprises several patch fields 16.

[0037] For illustration purposes, the patch fields 16 are drawn distinctly from one another, in reality, however, the patch fields 16 define a continuous antenna area 22. In particular, the patch fields 16 and thus the antenna area 22 are/is free of cutouts.

[0038] As can be seen clearly in Figure 2, the multiband patch antenna 10 comprises five rectangular patch fields 16 being of different patch field types.

[0039] In the shown embodiment, the multiband patch antenna 10 comprises patch fields 16 of three different patch field types, namely a first patch field type A, a second patch field type B and a third patch field type C.

[0040] The multiband patch antenna 10 comprises exactly one patch field 16 of the first patch field type A, called first patch field 24 in the following.

[0041] Of the second patch field type B, two patch fields 16 are provided, called second patch fields 26 in the following. Of the third patch field type C also two patch fields 16 are provided, called third patch fields 28 in the following.

[0042] Of course, the number of patch fields 16 and patch field types A, B, C are only exemplary. Other numbers of patch fields 16 and patch field types are of course conceivable.

[0043] In the shown embodiment, all patch fields 16, regardless of the patch field type A, B, C are rectangular, wherein in the patch fields 16 of different patch field type A, B, C differ from one another in size.

[0044] The first patch field 24 is the center of the antenna area 22, i.e. of the multiband patch antenna 10 in a top view, and overlaps partly with each of the other patch fields 16, namely the two second patch fields 26 and the two third patch fields 28.

[0045] Each of the corners of the patch field 24 is overlapped with a corner of one of the other patch fields 16. The areas, in which the patch field 16 overlap are called overlapping areas O.

[0046] For example, with respect to Figure 2, the upper left corner and the upper right corner of the first patch field 24 overlap each with a corner of one of the second patch fields 26 and the bottom right-hand corner and the bottom left-hand corner of the first patch field 24 overlap each with a corner of one of the third patch fields 28, respectively.

[0047] In the shown embodiment, the feedpoint 18 is provided in the bottom left third patch field 28, in particular outside of the overlapping area O. Of course, the feedpoint 18 could also be arranged on any other patch field 16, for example on one of the second patch fields 26.

[0048] The feedpoint 18 is for example a coaxial feed

or an insert feed.

[0049] Figure 3 shows the patch fields 16, i.e. the antenna area 22, in greater detail.

[0050] The different sizes of the patch fields 24, 26, 28 of the different patch field types A, B, C become clearer in Figure 3.

[0051] For the sake of distinction, the direction of the y-axis of Figure 3 is referred to as the vertical direction and the direction of the x-axis is referred to as the horizontal direction. This nomenclature is, of course, independent of the mounting position of the multiband patch antenna 10.

[0052] The dimensions of each patch field type A, B, C are chosen such that a respective patch field has a predefined resonance frequency. The resonance frequency is the frequency of electromagnetic radiation emitted by the respective patch field 16 in conjunction with the ground plane 12, when fed with a feed signal through the feedpoint 18.

[0053] First patch fields 24 of the first patch field type A have a first resonance frequency f_1 , for example 2.44 GHz, the second patch fields 26 of the second patch field type B have a second resonance frequency f_2 , for example 5.25 GHz, and the third patch fields 28 of the third patch field type C have a third resonance frequency f_3 , for example 5.6 GHz.

[0054] The first resonance frequency f_1 , the second resonance frequency f_2 and the third resonance frequency f_3 differ from one another.

[0055] The first patch field 24, the second patch field 26 and the third patch field 28 together may emit electromagnetic radiation - when fed with a feed signal through feedpoint 18 - with a further frequency or one of the resonance frequencies f_1 , f_2 , f_3 .

[0056] The resonance frequency of a patch field can be determined by the so-called cavity model, which is known in the art, that yields the horizontal and vertical length of the patch field for a desired resonance frequency and a desired mode.

[0057] For example, the horizontal length a_1 and the vertical length a_2 of the first patch field 24 of the first patch field type A, the horizontal length b_1 and vertical length b_2 of the second patch fields 26 of the second patch field type B and the horizontal length c_1 and vertical length c_2 of the third patch fields 28 of the third patch field type C may be determined as shown in the following table, wherein c_0 is the speed of light in vacuum, and ϵ_{reff} is the effective permittivity at the specified frequency. The calculations are carried out for the dominant TM_{10} mode.

$$a_1 \quad \frac{c_0}{2 * f_1 * \sqrt{\epsilon_{\text{reff}}(f_1)}}$$

$$a_2 \quad \frac{c_0}{4 * f_1 * \sqrt{\epsilon_{\text{reff}}(f_1)}}$$

$$b_1 \quad \frac{c_0}{2 * f_3 * \sqrt{\epsilon_{\text{reff}}(f_3)}}$$

$$b_2 \quad \frac{c_0}{2 * f_3 * \sqrt{\epsilon_{\text{reff}}(f_3)}}$$

$$c_1 \quad \frac{c_0}{2 * f_2 * \sqrt{\epsilon_{\text{reff}}(f_2)}}$$

$$c_2 \quad \frac{c_0}{2 * f_2 * \sqrt{\epsilon_{\text{reff}}(f_2)}}$$

[0058] In the shown embodiment, the arrangement of the patch fields 16, and thus the antenna area 22, is symmetrical with respect to an axis S that runs vertically, i.e. parallel to the y-axis, and through the geometric center D of the patch fields 16, i.e. antenna area 22, which is in the shown embodiment also the geometric center of the first patch field 24.

[0059] This geometric center of the antenna area 22 is regarded as the origin of the coordinate system of Figure 3.

[0060] The second patch fields 26 are spaced apart by a distance d_2 and the third patch fields 28 are spaced apart by a distance d_3 .

[0061] In the shown embodiment, distance d_2 and distance d_3 are about, in particular exactly equal to one another and correspond to the horizontal length c_1 of the third patch fields 28. Because of the symmetry, the distance of the second patch fields 26 and the third patch fields 28 from the vertical axis S (y-axis) amounts to half of distance d_2 , half of distance d_3 , respectively.

[0062] It is of course conceivable, that the distances d_2 , d_3 are different from one another. In this case, distances d_2 , d_3 may be about or particularly exactly equal to the horizontal length b_1 , c_1 of the second and third patch fields 26, respectively.

[0063] The left-hand side second patch field 26 and third patch field 28 are spaced apart by a vertical distance e. The right-hand side second patch field 26 and third patch field 28 are also spaced apart by the same vertical distance e.

[0064] The vertical distance e may be chosen such that the sum of the vertical distance e, the vertical length b_2 and the vertical length c_2 is about or exactly equal the

horizontal length a_1 so that the vertical length of the whole antenna area 22 is the horizontal length a_1 and thus half a wavelength of electromagnetic radiation with a frequency f_1 .

[0065] With respect to the geometric center D, in the shown embodiment, the location of the feedpoint 18 is 10.691 mm in the horizontal direction and 13.586 mm in the vertical direction on one of the third patch fields 28.

[0066] For example, the described parameters may take the following values $f_1 = 2.44$ GHz, $f_2 = 5.25$ GHz, $f_3 = 5.6$ GHz, $a_1 = 28.572$ mm, $a_2 = 15.945$ mm, $b_1 = 11.406$ mm, $b_2 = 12.101$ mm, $c_1 = 12.730$ mm, $c_2 = 12.783$ mm, $d_2 = d_3 = 12.23$ mm and $e = 4.362$ mm. The feedpoint 18 lies at $x = 10.691$ mm and $y = -14.586$ mm. The thickness of the ground plane 12 and support layers 14 is 0.035 mm and the thickness of the support layer 14 is 1.55 mm.

[0067] The deviations from the seemingly exact relations above are due to a numeric optimization. The values are still to be regarded as about equal to the relations given in the equations above.

[0068] The multiband patch antenna 10 of this design has an improved radiation characteristic meaning that it has a highly directional radiation characteristic, wherein at the same time the thickness of the multiband patch antenna 10 is small.

Claims

1. Multiband patch antenna, in particular a multiband PCB antenna, comprises a ground plane (12), at least one feedpoint (18), and at least two different patch fields (16; 24, 26, 28) being of at least two different patch field types (A, B, C), wherein each patch field type (A, B, C) is designed for a different predefined resonance frequency (f_1 , f_2 , f_3), wherein at least two of the patch fields (16; 24, 26, 28) have overlapping areas (O), and wherein the feedpoint (18) is positioned in a way that, when a feed signal is fed to the feedpoint (18), each of the at least two patch field (16; 24, 26, 28) emits electromagnetic radiation having the frequency of the predefined resonance frequency (f_1 , f_2 , f_3) of the respective patch field (16; 24, 26, 28) and/or a combination of two or more of the at least two patch fields (16; 24, 26, 28) emits electromagnetic radiation having a frequency of one of the resonance frequencies (f_1 , f_2 , f_3) or a further frequency.
2. Multiband patch antenna according to claim 1, **characterized in that** the at least two patch fields (16; 24, 26, 28) are free of cutouts and/or define a continuous antenna area (22).
3. Multiband patch antenna according to claim 1 or 2, **characterized in that** the at least two patch fields

(16; 24, 26, 28) have a rectangular geometry and/or that the patch fields (16; 24, 26, 28) of the at least two patch field types (A, B, C) have different sizes.

4. Multiband patch antenna according to any one of the preceding claims, **characterized in that** the vertical length (a_2 , b_2 , c_2) and/or the horizontal length (a_1 , b_1 , c_1) of the patch fields (16; 24, 26, 28) depends on the resonance frequency (f_1 , f_2 , f_3) of the respective patch field type (A, B, C).
5. Multiband patch antenna according to any one of the preceding claims, **characterized in that** for at least one of the at least two patch field types (A, B, C) two patch fields (16; 24, 26, 28) are provided.
6. Multiband patch antenna according to any one of the preceding claims, **characterized in that** the multiband patch antenna (10) is symmetrical with respect to an axis (S), particularly wherein the axis (S) extend through the geometric center (C) of the patch fields (16; 24, 26, 28).
7. Multiband patch antenna according to any one of the preceding claims, **characterized in that** the ground plane (12) is quadratic and/or has a cutout for each of the at least one feedpoint (18) only, in particular that the ground plane (12) is free of cutouts.
8. Multiband patch antenna according to any one of the preceding claims, **characterized in that** the multiband patch antenna (10) comprises a support layer (14) being provided between the at least one patch field (16; 24, 26, 28) and the ground plane (12), wherein the support layer (14) has a via for each of the at least one feedpoint (18) only, in particular that the support layer (14) is free of vias.
9. Multiband patch antenna according to any one of the preceding claims, **characterized in that** the at least one feedpoint (18) is provided as a coaxial feed or an insert feed.
10. Multiband patch antenna according to any one of the preceding claims, **characterized in that** a first patch field (24) of a first patch field type (A) with a first resonance frequency (f_1), at least one second patch field (26) of a second patch field type (B) with a second resonance frequency (f_2) and at least one third patch field (28) of a third patch field type (C) with a third resonance frequency (f_3) are provided, wherein the first patch field (24) partly overlaps with the at least one second patch field (26) and the at least one third patch field (28), particularly wherein the at least one second patch field (26) and the at least one third patch field (28) do not overlap.
11. Multiband patch antenna according to claim 10,

characterized in that the at least one feedpoint (18) is located at the at least one second patch field (26) and/or at the least one third patch field (28).

12. Multiband patch antenna according to claim 10 and 11, **characterized in that** the at least one second patch field (26) and at the least one third patch (28) field are spaced apart by a vertical distance (e), wherein the sum of the vertical distance (e), the vertical length (b_2) of the at least one second patch field (26) and the vertical length (c_2) of the at least one third patch field (28) is about equal to the horizontal length (a_1) of the first patch field (24). 5
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13. Multiband patch antenna according to any one of the claims 10 to 12, **characterized in that** exactly one first patch field (24), exactly two second patch fields (26) and exactly two third patch fields (28) are provided, particularly wherein the two second and two third patch fields (26, 28) each overlap with one of the corners of the first patch field (24). 15
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14. Multiband patch antenna according to claim 13, **characterized in that** the two third patch fields (28) are spaced apart by a third horizontal distance (d_3), wherein the third horizontal distance (d_3) is about equal to the horizontal length (c_1) of the third patch fields (28) and/or that the two second patch fields (26) are spaced apart by a second horizontal distance (d_2), wherein either the second horizontal distance (d_2) is about equal to half of the horizontal length (b_1) of the second patch fields (26) or the second horizontal distance (d_2) is about equal to the third horizontal distance (d_3). 25
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15. Multiband patch antenna according to any one of the claims 10 to 14, **characterized in that** the geometric center (D) of the first patch field (24) is the geometric center of the patch fields (16; 24, 26, 28). 40

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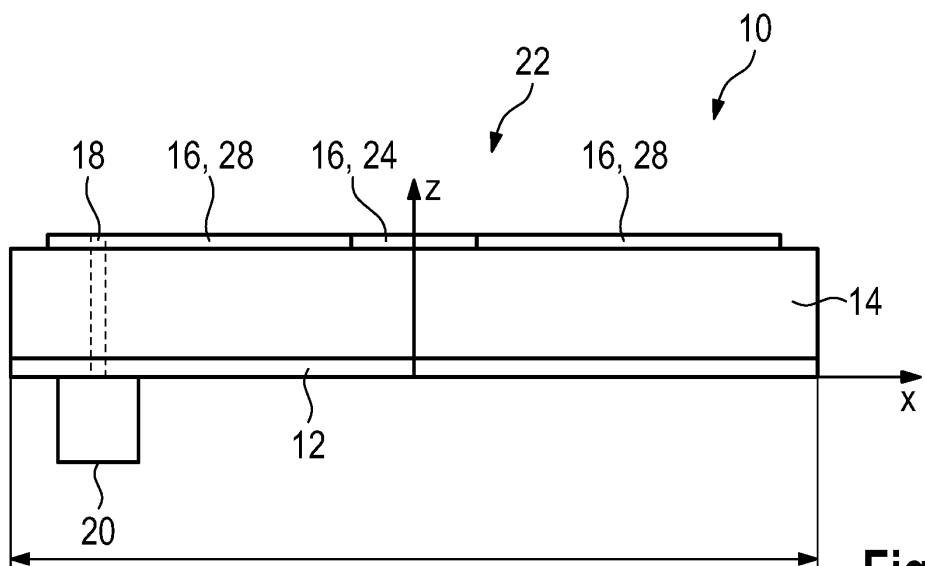


Fig. 1

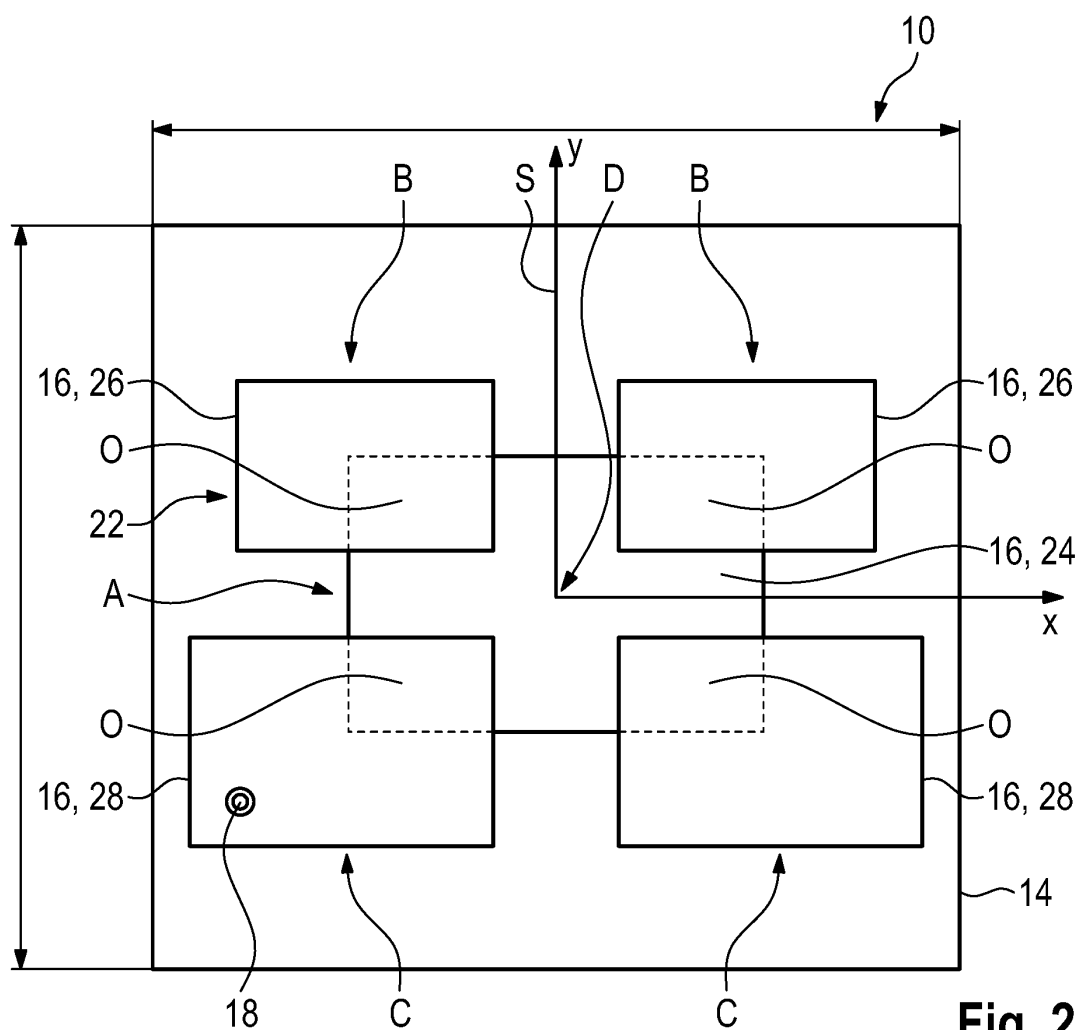


Fig. 2

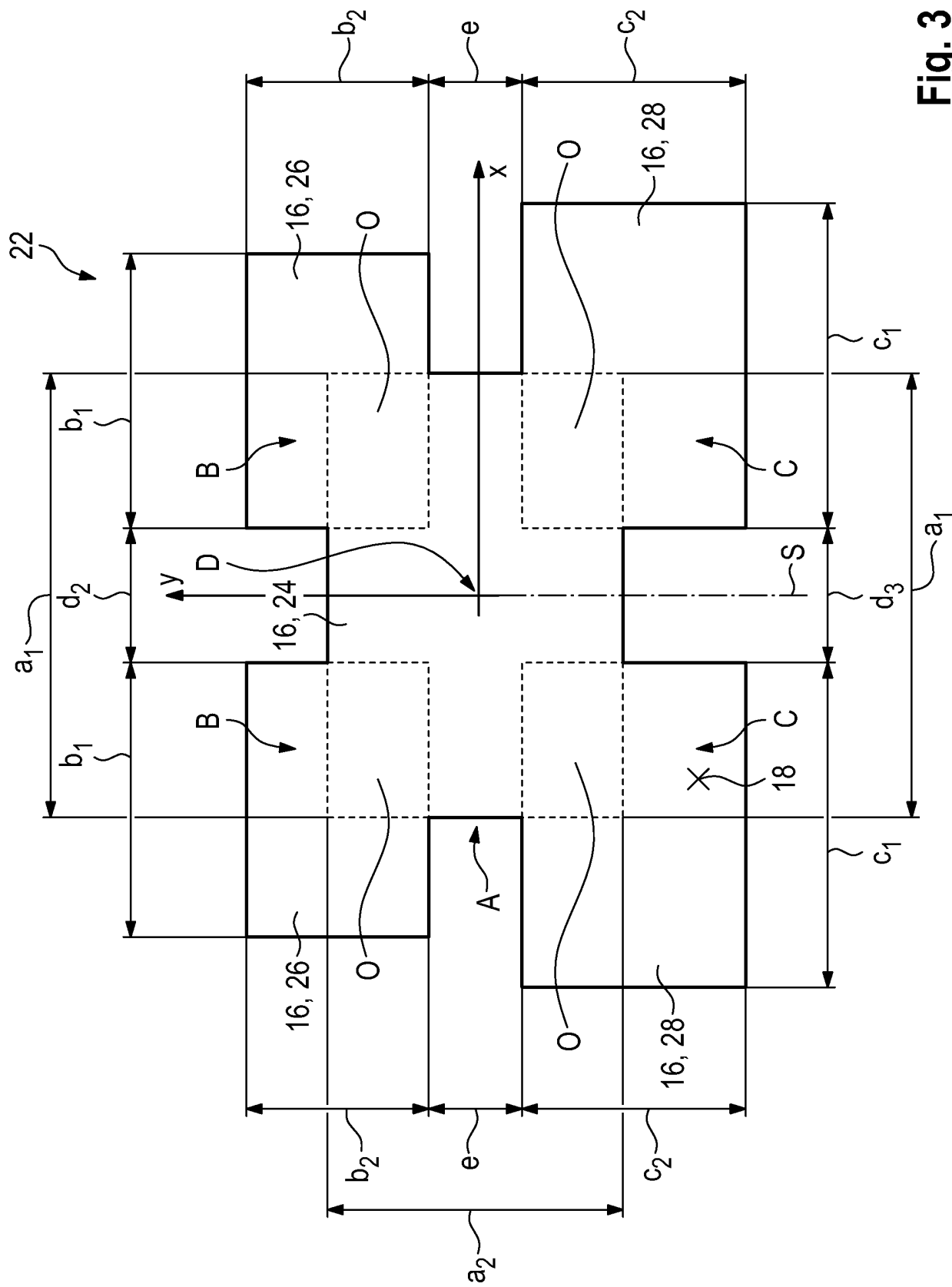


Fig. 3



EUROPEAN SEARCH REPORT

Application Number
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EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 2009/058731 A1 (GEARY KEVIN [US] ET AL) 5 March 2009 (2009-03-05) * figures 1-4, 9, 10 * * paragraph [0001] * * paragraph [0005] - paragraph [0008] * * paragraph [0026] * * paragraph [0028] - paragraph [0031] * * paragraph [0033] - paragraph [0036] * * paragraph [0040] - paragraph [0045] * * paragraph [0047] - paragraph [0051] * -----	1-11,13, 15 12,14	INV. H01Q9/04 H01Q5/371 H01Q21/06
A	US 2017/358863 A1 (STEPANENKO ANTON PAVLOVICH [RU] ET AL) 14 December 2017 (2017-12-14) * figures 4, 6A-6D, 9A-14B, 35A-35G * * paragraph [0073] * * paragraph [0081] - paragraph [0085] * * paragraph [0093] - paragraph [0100] * * paragraph [0122] * * paragraph [0159] - paragraph [0165] * -----	1-15	
A	EP 1 070 366 A1 (UNITED KINGDOM GOVERNMENT [CA]; LAFLEUR PHILIPPE [CA]) 24 January 2001 (2001-01-24) * figures 1-7, 10, 11 * * paragraph [0004] - paragraph [0008] * * paragraph [0018] * * paragraph [0020] - paragraph [0038] * -----	1-15	TECHNICAL FIELDS SEARCHED (IPC) H01Q
A	KR 101 942 343 B1 (KOREA ADVANCED INST SCI & TECH [KR]) 25 January 2019 (2019-01-25) * figure 1 * * paragraph [0031] - paragraph [0040] * -----	1-15	
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 7 August 2019	Examiner Gehrmann, Elke
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	

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 19 15 8830

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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07-08-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009058731 A1	05-03-2009	CN 101378146 A	04-03-2009
		DE 102008039776 A1	23-04-2009
		US 2009058731 A1	05-03-2009
US 2017358863 A1	14-12-2017	AU 2015409721 A1	26-04-2018
		EP 3353854 A1	01-08-2018
		US 2017358863 A1	14-12-2017
		WO 2017052400 A1	30-03-2017
EP 1070366 A1	24-01-2001	AT 236463 T	15-04-2003
		AU 1746499 A	12-07-1999
		CA 2225677 A1	22-06-1999
		DE 69813035 T2	18-03-2004
		EP 1070366 A1	24-01-2001
		US 6133882 A	17-10-2000
		WO 9933143 A1	01-07-1999
KR 101942343 B1	25-01-2019	KR 101942343 B1	25-01-2019
		US 2019067834 A1	28-02-2019