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(54) PRINTED ANTENNA FOR RECEIVING AND/OR TRANSMITTING RADIO FREQUENCY SIGNALS

(57) The object of the present invention is an antenna on a small printed circuit board without this adversely affecting the parameters of the antenna (directivity, bandwidth) or complicating the manufacturing process thereof. The printed antenna for the reception and/or transmission of radio frequency signals contains at least one active element, preferably of the monopole type and whose structure defines a direction of maximum radiation, and which has at least one impedance adaptor element and is characterised in that the at least one impedance adaptor element has at least one printed conductive element electrically connected to the active element.

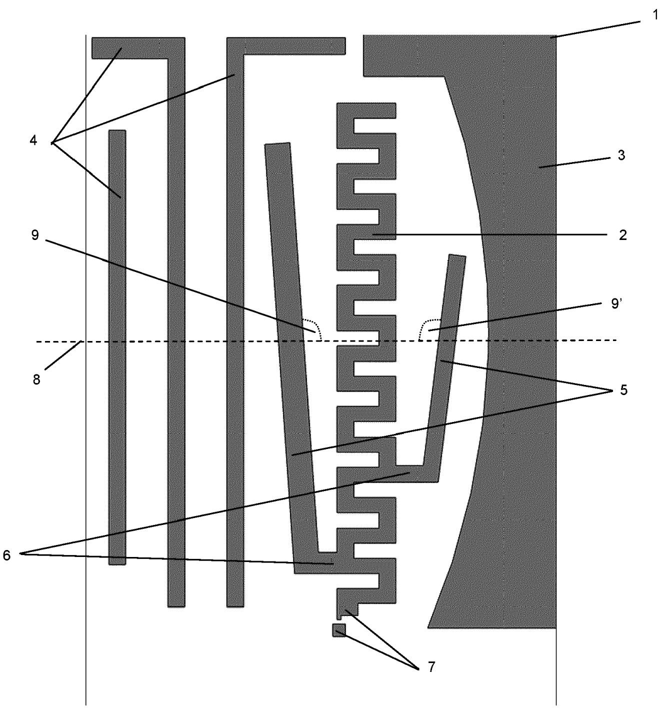

Fig. 1

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Description

TECHNICAL SECTOR

[0001] The present invention relates to a printed antenna for receiving and/or transmitting radio frequency signals, as claimed in claim number 1.

BACKGROUND OF THE INVENTION

[0002] Traditional antennas are known and are described in many documents. In order to obtain antennas of a reduced size that facilitate, for example, their integration in different devices (mobile phones, GPS devices, etc.) or their indoor installation with a low visual impact, an antenna manufactured by printed technology, and in particular microstrip technology, has already been described in multiple publications. Examples of such publications are the General Motors LLC Patent Application US2003160730A1 or the Televés European Patent EP0540899.

[0003] In the case of a Yagi antenna, for example, the traditional antennas are comprised of a dipole-like active element, which is a balanced element and which must be connected to an unbalanced element, such as a coaxial cable, or the input of an amplifier (usually via a microstrip line). This connection implies the need to make an impedance transformation by means of a *balun* (*balanced to unbalanced*) type device, be this a discrete component or by means of a printed element.

[0004] Such impedance transformations are performed by resonant structures, i.e. impedance transformations through lines with a length of $\lambda/4$ or similar. Document CN106785482A (Huaqiao University) describes a Yagi antenna wherein this technique is applied. However, this solution entails a reduction in the antenna bandwidth, so in many cases it is not suitable. This reduction in bandwidth also arises in any other type of antenna with a different radiation diagram (e.g. omnidirectional antennas).

[0005] Alternative structures have been proposed in order to achieve an increase in bandwidth, as disclosed in document KR20150124619, which proposes the use of a double dipole, with the dipoles separated from each other by a fraction of wavelength (multiple of $\lambda/2$), so that both are in phase and combine their effects. However, the disadvantage of this solution is that the size of the antenna increases with respect to a single-dipole antenna, as well as entailing a greater manufacturing cost due to the need to incorporate more complex power supply circuits that require double-sided technologies with a connection between both sides.

[0006] Another solution is that described in patent application US5220335A, consisting of an unbalanced printed antenna, and therefore with no need for an impedance transforming adaptor element. However, this solution consists of an antenna called a "patch" antenna, and in which the ground plane must be located on the other side of the printed circuit, which does not solve the increase in complexity involved in the use of double-sided circuits connected to each other.

[0007] The document "A Tunable multi-band meander line printed monopole antenna lor MIMO systems. Antennas and Propagation (EUCAP)" (ALiREZA MALLAHZADEH et al Proceedings 01 the 5th European Conference on 20110411 IEEE., 11 /04/2011) presents a tuneable meander line multi-band printed monopole antenna for a multiple input and multiple output (MIMO) system. The proposed meander line monopole antenna can create a single resonance in the WLAN range. Two additional resonances are achieved by placing two vertical resonance trajectories with a length of N2 over the first meander line. Inserting two paths into the antenna feed line produces the correct impedance.

[0008] This solution has the drawback that the additional meanders that are added to create new resonances are located perpendicular to the first meander, which increases the size of the antenna. In addition, the proposed structure itself limits the number of total meanders and therefore that of resonant frequencies to three. Finally, this design aims to create several resonances in independent frequencies, minimizing the feedback between the same, and not to increase the bandwidth at a given frequency band.

[0009] The document "Compact and wideband planar loop antenna with microstrip to parallel strip balun feed using metamaterials" (KHANJARI SHIMA POORGHOIAM et al., AEU - International Journal of Electronics and Communications) presents a high gain, broadband, compact flat loop antenna, implemented with metamaterials.

[0010] The antenna consists of a rectangular printed loop with two holes, a corrugated reflector to reduce the size of the antenna and a dipole; a parasitic strip and metamaterials are also used in the structure of the antenna. Corrugating the reflector means that the effective electrical length increases and the resonance frequency decreases, and the current in the reflector flows over a longer path, 10, resulting in a reduction in size. The parasitic strip and the metamaterials act as a high-frequency quasi-Yagi-Uda director, and also improve the main directivity. In addition, the use of metamaterials improves antenna gain and the adaptation of impedance.

[0011] This solution has the drawback that it requires a special feed structure located perpendicular to the antenna, which considerably increases the size and complicates the manufacturing process. Furthermore, the use of structures called metamaterials limits the use of this solution to certain types of printed circuit substrates. It is also a specific solution for a certain type of Yagi antenna, which limits its use in other types of antennas.

DESCRIPTION OF THE INVENTION

[0012] The object of the present invention is an antenna on a small printed circuit board without this adversely affecting the parameters of the antenna (directivity, bandwidth) or complicating the manufacturing process thereof. This objective is achieved with a device as described in the claims, and has a plurality of advantages.

[0013] In an **example** according to the invention, the printed antenna for the reception and/or transmission of radio frequency signals contains at least one active element, preferably of the monopole type and whose structure defines a direction of maximum radiation, and which has at least one impedance adaptor element, and is characterized in that the at least one impedance adaptor element has at least one printed conductive element electrically connected to the active element.

[0014] This **example** has the advantage that it enables an antenna design without the need for separate, independent radiating elements for impedance adaptation when performed directly on the radiating element(s), which implies a reduction in the size of the antenna. This is an antenna structure with the impedance adapted in the work band, directly by design, to the connection with external elements (such as cables, amplifiers or active or passive devices that can be connected to the antenna) without the need for additional elements.

[0015] In another **example** according to the invention, the printed antenna for receiving and/or transmitting radio frequency signals is characterized in that the at least one active element and the at least one impedance adaptor element are on a same plane.

[0016] This **example** has the advantage of reducing manufacturing complexity, as well as reducing the use of materials, by having all its elements disposed on a same layer of the printed circuit. This enables the manufacture of the antenna to be used in a single-layer circuit, and therefore in a single-sided printed circuit.

[0017] In the case of double-sided printed circuits, this example would enable the use of the other side of the circuit to incorporate other elements such as, but not limited to, filters or amplification circuits into the antenna. In the case of multilayer circuits, other layers could likewise be used for the elements described by making the appropriate connections between the different layers.

[0018] In another **example** according to the invention, the antenna has at least one reflector element.

[0019] The presence of a reflector provides the advantage of enabling the modification of the radiation diagram of the antenna by increasing the front-rear ratio.

[0020] In another **example** according to the invention, the printed antenna for the reception and/or transmission of radio frequency signals is characterized in that the at least one active element, the at least one impedance adaptor element and the at least one reflector element are on a same plane.

[0021] This **example** has the advantage of reducing manufacturing complexity as well as reducing the use of materials by having such elements disposed on the same layer of the printed circuit. This enables the manufacture of the antenna to be used in a single-layer circuit, and therefore in a single-sided printed circuit.

[0022] As in the previous **example**, in the case of double-sided printed circuits, this example would enable the use of the other side of the circuit to incorporate other elements such as, but not limited to, filters or amplification circuits into the antenna. In the case of multilayer circuits, other layers could likewise be used for the elements described by making the appropriate connections between the different layers.

[0023] In another **example** according to the invention, the antenna has at least one director element.

[0024] This **example** has the advantage of increasing the directivity of the antenna, that is, increasing the gain in a given direction.

[0025] In another **example** according to the invention, the printed antenna for the reception and/or transmission of radio frequency signals is characterized in that the at least one active element, the at least one impedance adaptor element and the at least one director element are on a same plane.

[0026] The advantages inherent to the two above examples are similar in this case.

[0027] In another **example** according to the invention, the printed antenna for the reception and/or transmission of radio frequency signals is characterized in that the at least one impedance adaptor element is disposed perpendicular to the maximum radiation direction of the active element.

[0028] This **example** has the advantage of reducing the size of the antenna structure, further facilitating the decoupling between the impedance adaptor element and the active element.

[0029] As perpendicular, one must take into account the non-significant inclination of the impedance adaptation element(s) with respect to perpendicular to the direction of maximum radiation of the active element, which enables said reduction in the size of the antenna circuit; that is, an inclination of the impedance adaptor element(s) with respect to the perpendicular to the direction of maximum radiation of the element, of between -15° and 15°.

[0030] In another **example** according to the invention, the printed antenna for the reception and/or transmission of radio frequency signals is characterized in that it has a ground area.

[0031] The term "ground area" is used to designate what is commonly known as "ground plane" (zero voltage), to differentiate it from the term "plane" as a geometric concept used for each of the layers of a printed circuit.

[0032] This example has the advantage that the positioning of a ground area makes it possible to improve the directivity of the antenna by increasing the gain in the direction of maximum radiation of the active element.

[0033] In another **example** according to the invention, the printed antenna for the reception and/or transmission of radio frequency signals is characterized in that the ground area is located on the same plane as the at least one active element, the at least one reflector element, the at least one director element and the at least one impedance adaptor element.

[0034] The fact that this area is coplanar with the structure of the antenna enables a reduction in size and the limitation of the manufacture to a single-layer (-side) circuit.

[0035] In another **example** according to the invention, the printed antenna for the reception and/or transmission of radio frequency signals is characterized in that the ground area is disposed in such a way as to define the desired characteristics of the antenna.

[0036] The size and positioning of the ground area on the circuit, likewise its distance from the elements that make up the antenna (director elements, reflector elements, impedance adaptor elements, active element) influences the radiation diagram thereof, as well as its bandwidth. Therefore, the selection of a certain shape, extension, position and profile of the ground area in the circuit will contribute to the improvement of the characteristics of the antenna required for a given application.

[0037] The size of the ground area conditions the gain and thus the radiation diagram, in such a way that a broader ground area provides the antenna with a greater gain. The separation with respect to the active element and the director elements will condition the working frequency and the bandwidth of the same. It also conditions the design in terms of the impedance of the antenna, which will increase or decrease depending on the distance from the active element and from the impedance adaptor elements. As for the distance from the reflector, this conditions the front/rear ratio, and therefore the radiation diagram.

[0038] This **example** therefore has the advantage of enabling the obtaining of an antenna with a more significant gain in wavelength fraction active element sizes ($< \lambda/2$) depending on the distance from the ground area to the dipole, likewise different directivities thereof (distance to the director elements and/or to the reflector elements), and in the impedance of the antenna (distance to the impedance adaptor elements).

[0039] In another **example** according to the invention, the printed antenna for the reception and/or transmission of radio frequency signals is characterized in that the at least one director element and/or at least one reflector element is connected to the ground area. This is therefore a particular case of the above example, wherein the distance from at least one director and/or at least one reflector to the ground area is zero.

[0040] This **example** has the advantage that:

- On the one hand, the connection of one or more director elements to the ground area grants the possibility of configuring the bandwidth and/or the working frequency of the antenna depending on the application for which it is intended.
- On the other hand, the connection of one or more reflector elements to the ground area grants the possibility of shaping the antenna location diagram both in transmission and in reception, modifying the front/rear ratio.

[0041] In another **example** according to the invention, the printed antenna for the reception and/or transmission of radio frequency signals is characterized in that the at least one active element and/or the at least one impedance adaptor element is meander-shaped.

[0042] This **example** has the advantage that it minimizes the space occupied by an active element and/or an impedance adaptor element for a given length of the elements (length that will be conditioned by the frequency band and the directivity that it is intended to achieve in the case of the active element, and the impedance to which the antenna is intended to be adapted in the case of the impedance adaptor element), with the consequent reduction in size of the antenna.

BRIEF DESCRIPTION OF THE DRAWINGS

[0043] To complement the description being made herein, and for the purpose of aiding in a better understanding of the characteristics of the invention, a set of drawings is attached as an integral part of said description wherein, by way of illustration and not limitation, the following has been represented:

Figure 1.- Example of an embodiment of the antenna according to the invention.

Figure 2.- Example of an embodiment of the antenna with a ground area, according to the invention.

Figure 3.- Example of an embodiment of the antenna with a reflector element and a director element connected to the ground area, according to the invention.

Figure 4.- Example of an embodiment of the antenna with a loop-shaped active element, according to the invention.

LIST OF REFERENCES

[0044]

1	Printed antenna according to the invention
2	Active element
3	Reflector element
4	Director elements
5	Impedance adaptor elements
6	Printed conductive elements connecting impedance adaptor element to active element
7	Signal input/output terminals
8	Direction of maximum radiation of the active element.
9, 9’	Angles between impedance adaptor elements and the direction of maximum radiation
10	Ground area (plane)
11	Connection between reflector and ground area (plane)
12	Connection between director element and

ground area (plane)

PREFERRED EMBODIMENT OF THE INVENTION

[0045] Hereunder, and by way of non-limiting example, a preferred embodiment of the invention is shown. Figure 1 portrays an image of a preferred embodiment of the antenna.

[0046] Said antenna 1 contains a monopole-type active element 2, a reflector element 3 that enables the sending of the reflections of the received signal towards the active element 2, three director elements 4 that enable the orienting of the signal received towards the area of greatest gain of the antenna, two impedance adaptor elements 5 connected by means of a printed conductive element to the active element 2, and an input/output terminal 7 for the connection of the antenna to an external element (cable, amplifier, etc.).

[0047] The active element 1 consists of a meander that minimizes the surface occupied on the printed circuit board for a given dipole length. Such an active element could be of any other shape. By way of a non-limiting example, the active element could be of any shape from a simple rectilinear printed line to a loop, as shown in a subsequent embodiment.

[0048] The antenna according to this preferred embodiment has a reflector element 3 at the rear area of the antenna (defined as the area in which direct signal transmission/reception is not intended). Alternatively, and as will be understood by a person skilled in the art, both the number, shape, length and separation between said reflectors 3, likewise the separation of these from the active element 2, may be diverse, depending on the characteristics of the antenna (front/rear ratio, working band and bandwidth) that it is intended to achieve. By way of a non-limiting example, two V-shaped reflectors could be located forming an angle of 45 ° between the same and separated from the active element by a minimum of 2 mm.

[0049] In this preferred embodiment, three director elements 4 of different lengths are employed; these direct the signal towards the monopole. As will be understood by a person skilled in the art, the number, shape, length and spacing between said directors 4 and from these to the active element 2 may be diverse, depending on the characteristics of the antenna (gain in the direction of maximum radiation, front/rear ratio, working band and bandwidth) intended to be achieved (for example, without being limited thereto, 5 directors of a semi-circular shape, with identical or logarithmic separation between them with the nearest at a minimum distance of 2 mm from the active element).

[0050] The impedance adaptor elements 5 connected by a printed conductive element to the active element 2 shall be designed in such a way that they adjust the impedance of the antenna with regard to connection with other devices or external elements such as, but not limited to, cables, amplifiers or any other devices for the processing of radio frequency signals. Said adaptor elements may be of various shapes, lengths and distance to the active element 2 from the area furthest away from the active element 5 itself. Such characteristics will depend on the application requirements of the transmitting/receiving antenna in relation to its bandwidth and/or directivity, as is well known in the state of the art.

[0051] A variant of this preferred embodiment would make it possible to incorporate an additional number of active elements 2 with or without at least one impedance adaptor element 5, thereby making it possible to modify the directivity of the antenna 1, incorporating impedance adaptor elements 5 only in those in which it is deemed necessary.

[0052] In Figure 1, the impedance adaptor elements 5 are located in such a way, 9, 9' not being perpendicular to the direction of maximum radiation of the active element 8, but in a direction tending to alignment with said perpendicular in order to reduce the size of the antenna circuit.

[0053] On the other hand, in the embodiment, the adaptor elements 5 are located, one at the frontal area of the antenna (defined as the area in which the transmission/reception of a direct signal is intended) and another at the rear area of the antenna. Alternatively, the impedance adaptor elements could differ in number and/or shape from the described example, as well as being located indistinctly at the front or rear of the antenna.

[0054] Figures 2 and 3 portray, by way of a non-limiting example, the description of an antenna with a single active element that has two linear adaptor elements 5 located at the front of the antenna, perpendicular (9, 9') to the maximum radiation direction of the active element 8.

[0055] In the example of Figure 1, all the described elements (active element 2, reflector element 3, director elements 4, impedance adaptor elements 5, input/output terminal) are located on the same plane (side or layer), which would facilitate the design and manufacture on a single-layer printed circuit board, it being possible to use the other side thereof to incorporate other elements into the antenna, such as, but not limited to, an amplifier circuit or a filter for the selection/rejection of a given band. However, in other preferred embodiments, each of the elements described, likewise any combination or subset thereof, could be implemented on different planes (layers), and connecting the different layers together if deemed necessary, forming a multilayer circuit.

[0056] The preferred embodiment of Figure 1 has antenna input/output connection terminals, one of which must be grounded. However, figures 2, 3 and 4 portray embodiments wherein the ground terminal 7 is replaced by a ground area (plane) 10.

[0057] In another preferred embodiment according to Figure 2, the ground area (plane) 10 is located parallel to the direction of maximum radiation of the active element 8, which makes it possible to configure the directivity of the antenna 1.

[0058] In the preferred embodiment of Figure 3 it has a reflector element 3 and three director elements 4. The reflector 3 and one of the directors 4 are connected to the ground area. In this way, characteristics in conformity with the design to be implemented are obtained.

[0059] Finally, Figure 4 portrays another preferred embodiment of an antenna 1 with a single meander-shaped active element 2 that in turn has a single meander-shaped impedance adaptor 5, located at the frontal area of the antenna, and with a reflector element 3 with a concave profile located at the rear of the antenna. In this embodiment, the antenna has a ground area (plane) 10 located on the same plane as the remainder of the elements. As can be seen, the profile of the ground area is different in the vicinity of each of the elements, so that certain characteristics are achieved (directivity, radiation diagram, front-to-rear ratio, bandwidth and working frequency). Therefore, characteristics of the antenna 1 adapted to the specific application for which it is intended are obtained by performing a correct design of the characteristics of this ground area 10 (profile, positioning, distance to each of the elements).

Claims

1. A printed antenna for receiving and/or transmitting radio frequency signals (1) having:

- at least one active element, preferably of the monopole type (2), with a direction of maximum radiation (8), and having at least one impedance adaptor element (5), **characterised in that**:
- the at least one impedance adaptor element (5) has at least one printed conductive element electrically connected to the active element (2).

2. A printed antenna for receiving and/or transmitting radio frequency signals (1), as claimed in claim 1, **characterised in that**

- the at least one active element (2) and the at least one impedance adaptor element (5) are on a same plane.

3. A printed antenna for receiving and/or transmitting radio frequency signals (1), as claimed in the preceding claims, **characterised in that** it:

- has at least one reflector element (3),

4. A printed antenna for receiving and/or transmitting radio frequency signals (1), as claimed in claim 3, **characterised in that**

- the at least one active element (2), the at least one impedance adaptor element (5) and the at least one reflector element (3) are on the same plane.

5. A printed antenna for receiving and/or transmitting radio frequency signals (1), as claimed in the preceding claims, **characterised in that** it:

- has at least one director element (4),

6. A printed antenna for receiving and/or transmitting radio frequency signals (1), as claimed in claim 5, **characterised in that**

- the at least one active element (2), the at least one impedance adaptor element (5) and the at least one director element (4) are on the same plane.

7. A printed antenna for receiving and/or transmitting radio frequency signals (1), as claimed in the preceding claims, **characterised in that**

- the at least one impedance adaptor element (5) is disposed perpendicular to the direction of maximum radiation of the active element (8).

8. A printed antenna for receiving and/or transmitting radio frequency signals (1), as claimed in the preceding claims, **characterised in that**

- it has a ground area (10)

9. A printed antenna for receiving and/or transmitting radio frequency signals (1), as claimed in claim 8, **characterised in that**

- the ground area (10) is located on the same plane as the at least one active element (2) and the at least one impedance adaptor element (5).

10. A printed antenna for receiving and/or transmitting radio frequency signals (1), as claimed in claims 8 and 9, **characterised in that**

- the ground area (10) is disposed such that it defines desired characteristics of the antenna (1).

11. A printed antenna for receiving and/or transmitting radio frequency signals (1), as claimed in claims 3 to 10, **characterised in that**

- at least one director element (4) and/or at least one reflector element (3) is connected to the ground area (10).

12. A printed antenna for receiving and/or transmitting radio frequency signals (1), as claimed in all the preceding claims, **characterised in that**

- the at least one active element (2) and/or the at least one impedance adaptor element (5) is meander-shaped.

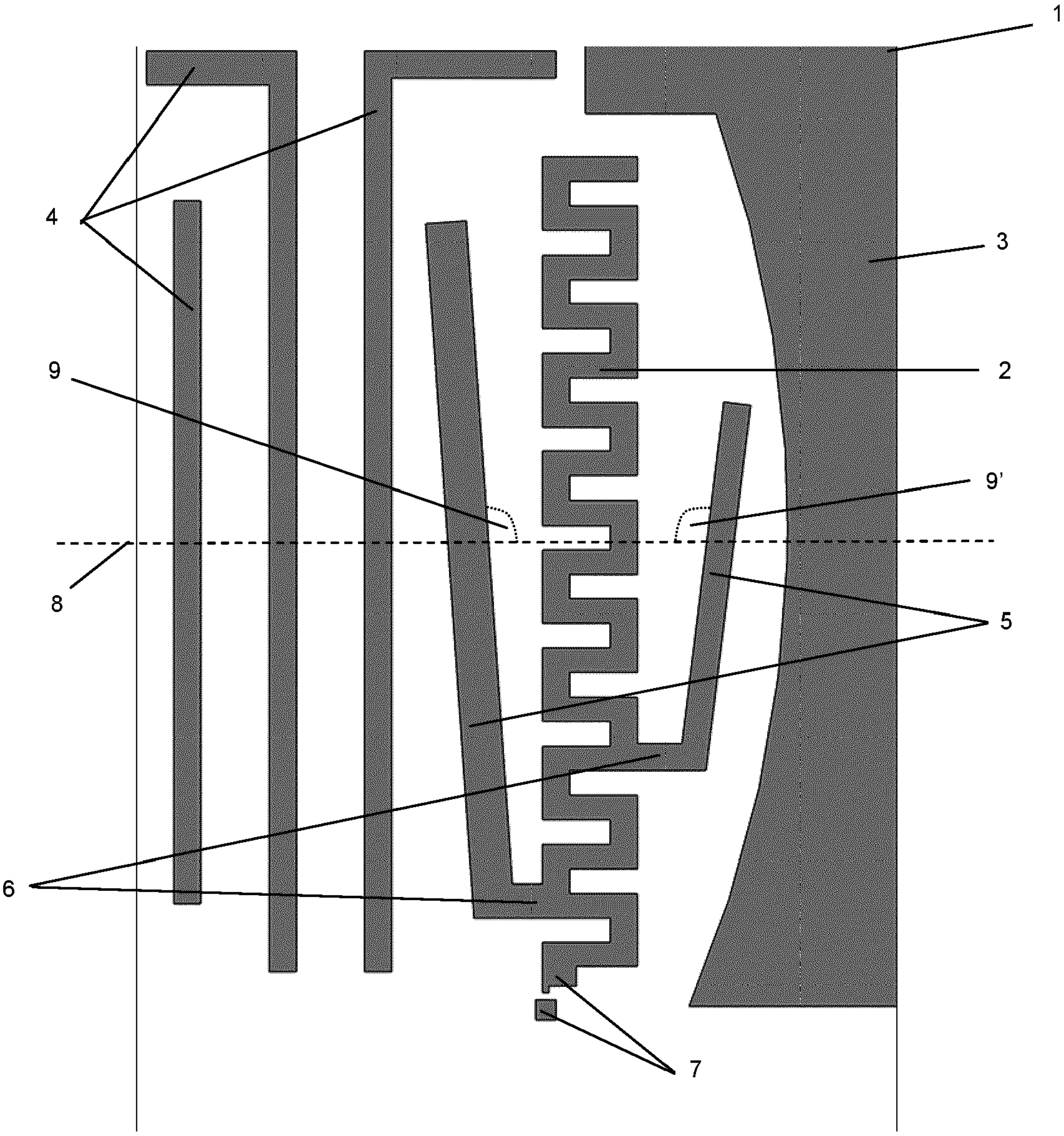

Fig. 1

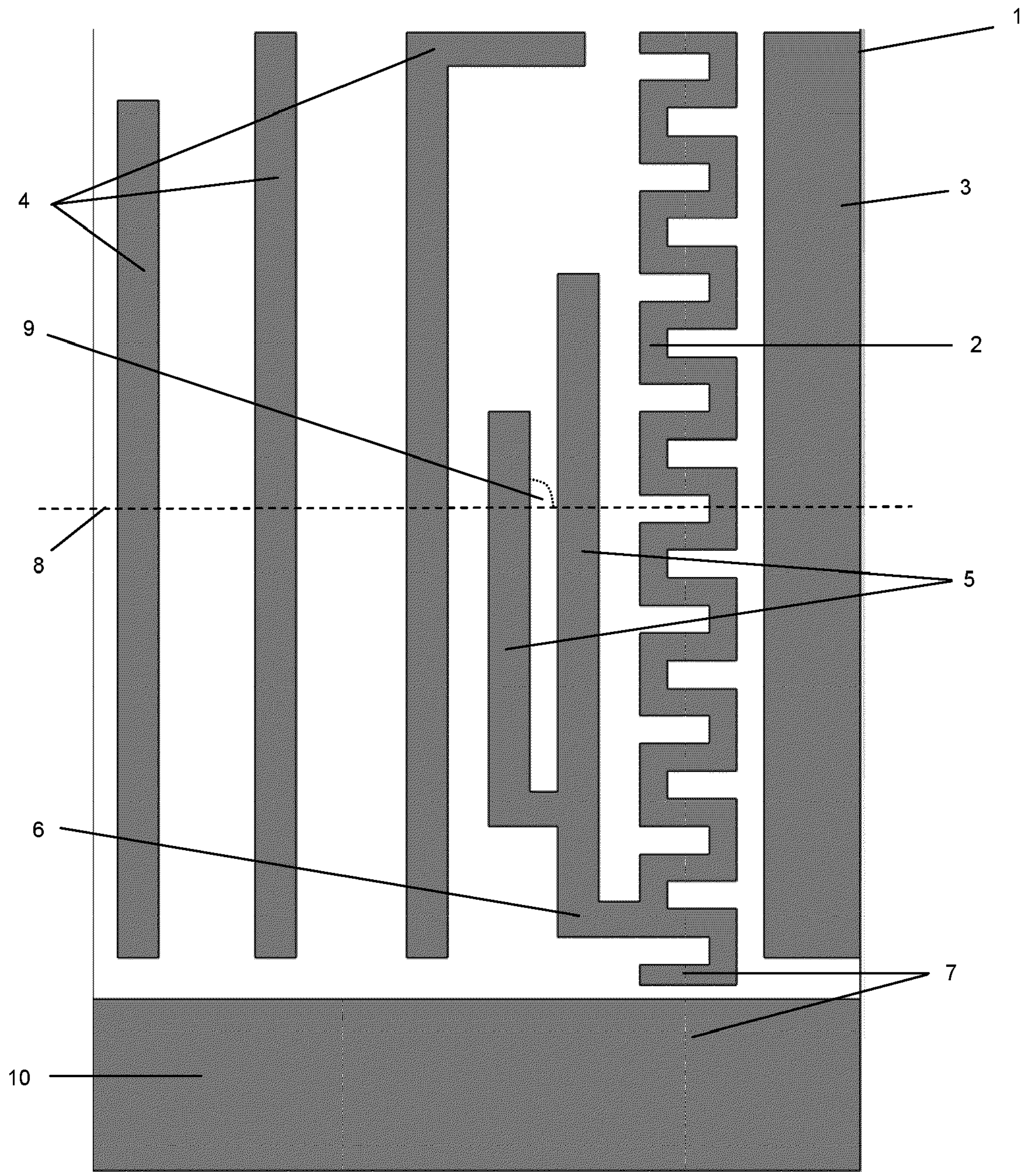

Fig. 2

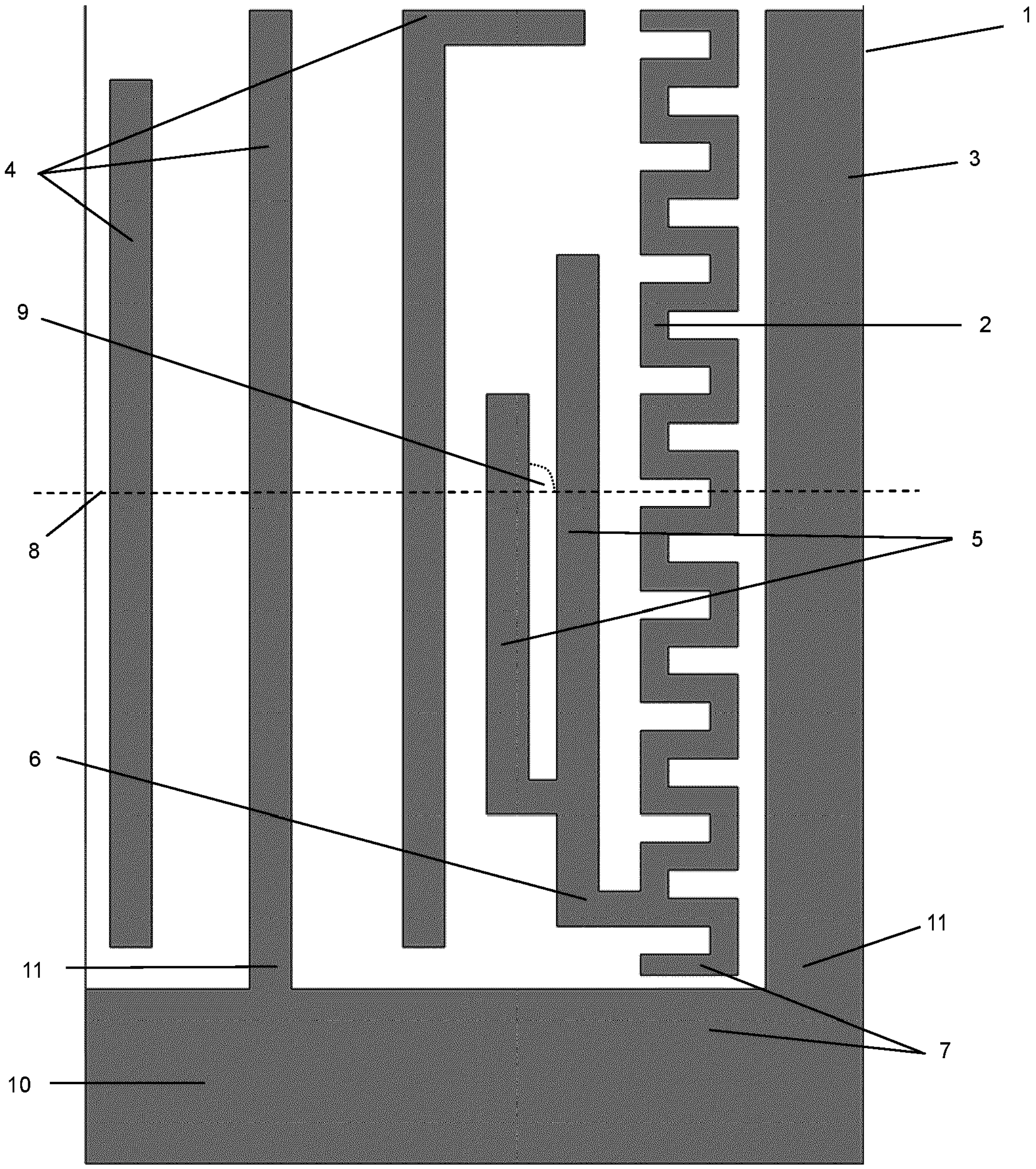

Fig. 3

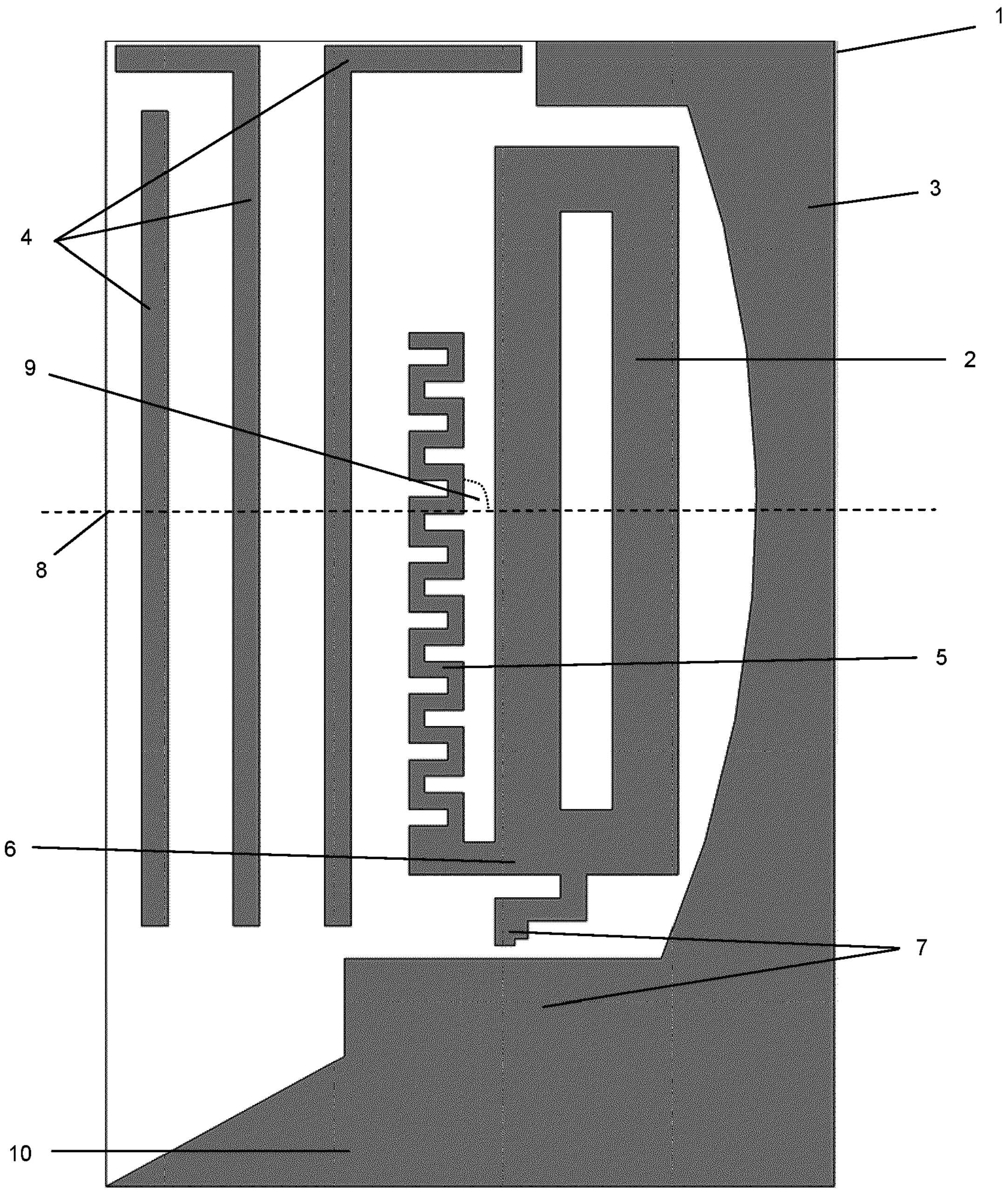

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 21 38 3075

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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			TECHNICAL FIELDS SEARCHED (IPC)
			H01Q

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	16 May 2022	Collado Garrido, Ana

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 21 38 3075

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16-05-2022

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

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