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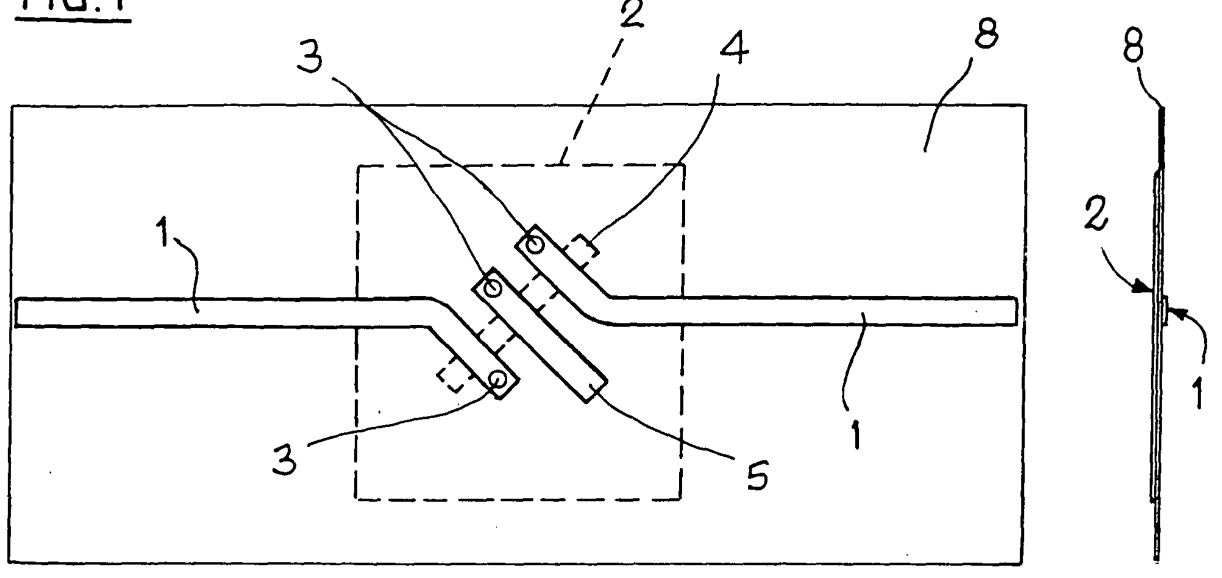
(54) A dielectric substrate single layer planar dipole antenna

(57) A dielectric substrate single layer planar dipole antenna comprises at least a radiant dipolar element made of two strips (1) having any shape such as linear, spiral, meander or like, printed on the front side of a thin dielectric substrate. On the back side of the said substrate a planar balanced feeding structure (balun) is implemented using a slot (4) etched on a thin metallic patch locally performing as ground plane (2).

Two metallized via-holes or rivets (3) very near to the edges of said slot (4) connect the radiating strips (1) to the ground plane. The two via-holes are disposed symmetrically with respect to the slot centre. A third feeding strip (5), etched on the same side of the said radiating strips, bridges over the centre of said slot and is connected to the ground through a via-hole (3) very near the slot edge. This third strip (5) constitutes the unbalanced input port of the balanced antenna, suitable for connecting the inner conductor of a coaxial cable whose outer conductor can be directly or indirectly connected to the ground plane.

FIG. 1



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Description

[0001] The present invention refers to a dielectric substrate single layer planar dipole antenna.

[0002] More particularly the present invention relates to a dielectric substrate single layer planar dipole antenna particularly suitable for wireless applications and remote control systems.

[0003] Many single layer antennas are known in the art. They can be used for short-distance radio-links, particularly for vehicular applications (locking and unlocking doors, activating antitheft devices and searching the car on a crowed parking area). Most of such antennas use the classical grounded monopole; alternatively a trace of the rear window defroster can be used, if available. More simply the antenna can be realised by a short piece of isolated conductor (wire) hidden inside the vehicle.

[0004] It is also possible to use the AM/FM whip on the car roof, if available, which radiates an isotropic horizontal pattern; this solution has the drawback that such antenna is sensitive only to vertical polarized waves.

[0005] It is worth noting that the wave radiated from the transmitter unit can be polarized and that the polarization can be arbitraly vertical, horizontal or slanted, because its polarization state depends on how said unit is oriented during the handling. Statistically, however, the horizontal polarization prevails because it corresponds to the more natural handling of the said transmitting unit.

[0006] When the receiving antenna is realised using a trace of the defrosting grid, the polarization state is variable and it is mainly determined by the interaction of the antenna with the vehicle metal body, which produces a remarkable depolarization effect. Nevertheless, in order to privilege the horizontal polarization, the antenna structure and position should be optimised during the design phase of the vehicle. This is often considered a burden from the most car producers because optimization studies increase the costs. Using instead a simple radiating wire inside the vehicle, the costs are reduced but the antenna performances become poor and unpredictable because the metallic body produces strong mismatching on a unbalanced antenna configuration.

[0007] The object of the present invention is to provide a simple, low cost highly efficient and reproducible planar antenna to be installed inside the vehicle, for instance on the dashboard, glasses, bumpers or other non-metallic parts of the car with minimal mechanical and aesthetical constrains.

[0008] Further object of the present invention is to provide an antenna easily reconfigurable and tuneable for operating on any vehicle type and installation place, offering good radiation efficiency also in presence of near metallic parts.

[0009] Further object of the present invention is to provide a linear polarized antenna easily to set for achieving a prevailing horizontal polarized pattern.

[0010] According to the present invention, these and other objects, which will be apparent from the following description, are achieved by the features in the characterising portion of claim 1.

[0011] Particularly, the planar antenna of the present invention is obtained by:

a) using a thin substrate layer as a support of a dipolar planar radiating element comprising at least a couple of printed strips or wires having any shape such as linear, spiral, meander or like, fed 180° out of phase to operate as a balanced dipole;

b) realising on the opposite side of the said substrate layer a thin metallized area (patch) where a slot operating as balanced/unbalanced transformer (balun) is etched, thus allowing an unbalanced feeding of the intrinsically balanced antenna by means of a coaxial cable and simultaneously avoiding that the presence of said cable could affect significantly the behaviour of the antenna;

c) connecting the inner ends of the dipole strips to said patch with two metallized via-holes or rivets symmetrically disposed with respect to the slot centre and near its main edges, in such a manner that the arms of the dipole are electrically in phase opposition;

d) introducing a third planar strip on the same side of the dipole arms that bridges the slot at its centre and is connected to the opposite patch through a via-hole or rivet;

e) feeding the antenna with a coaxial cable whose inner conductor is connected to said third strip and the outer conductor is connected to said patch;

f) providing that said via-holes can be replaced by lumped impedances and that other lumped impedances can be placed in series to the feeding and radiating strips in order to modify the electric parameters of the whole antenna;

g) providing that the feeding strip can be replaced by a coplanar waveguide (CPW) etched on the opposite side of the planar dipole, thus making easier the connection of the coaxial cable;

h) providing the possibility of varying shape, dimensions and configuration of the patch supporting the slot and the slot itself in order to optimize the radiation efficiency;

i) providing the possibility of conforming the two strips of the balanced dipole as spiral, meander or other shapes in order to reduce the overall dimensions of the antenna or using multiple couples of strips having the same or different feeding points in order to obtain a multiband/multifunction operation.

[0012] The main advantage of the present invention consists on the use of a simple slot etched on a ground patch smaller than the wavelength to transform the balanced input of a planar dipole into a unbalanced input, suitable for direct coaxial cable connection.

[0013] Moreover, by connecting the outer conductor of the coaxial cable with the point of the patch surface where the RF current reaches its minimum, it is possible to reduce the sensitivity of the antenna to the cable length and to the presence of near metallic bodies.

[0014] A further advantage consists in that the dipolar planar antenna, while maintaining its fundamental electromagnetic properties, can be properly designed to be optimally fitted on different parts of the vehicle (for instance inside the rear-view mirror) by assuming a rectangular or polygonal shape, planar or conformed to any curved surface.

[0015] A further advantage comes from the possibility of varying independently the length of both dipole arms and the dimensions or the shapes of the slot in order to optimize the antenna resonant frequency, bandwidth and impedance matching, after its placing in the chosen position inside the vehicle.

[0016] A further advantage consists in the possibility of embedding the planar strips constituting the dipole arms inside a multilayer of at least two layers of dielectric/magnetic material, in order to increase the antenna compactness.

[0017] The invention is described in detail in the following, with reference to the figures of the enclosed drawings that show some embodiments of the planar antenna of the present invention, reported by way of non limiting examples and wherein:

Fig. 1 shows a schematic frontal and side view of the radiating element, for a planar antenna according to the present invention, in a basic configuration constituted by two thin metallic strips having a linear shape; in this case, the slot realizing the balanced feeding has a rectangular shape and is tilted by 45° with respect to the line of the radiating element in order to minimize the reactance associated to the discontinuity of the lines constituting the radiating arms of the dipole,

Fig. 2 shows a schematic frontal view of the radiating element, according to the present invention, in a further embodiment comprising two thin metallic spiral-shaped strips and a ground plane of small dimensions where the balancing slot for the feeding (balun) is etched, that in this example has the shape of a butterfly. The connection points between the metallic strips and the lower ground plane are also visible, together with the central metallic strip where the feeding cable is connected,

Fig. 3 shows a schematic frontal view of the radiating element for a planar antenna according to the present invention, in a further embodiment comprising two thin metallic strips with a meander shape,

Fig. 4 shows the behaviour of the input reflection coefficient as a function of frequency, for the antenna of Fig. 2,

Fig. 5 shows the behaviour of the radiation diagram (gain) in the horizontal plane, for the antenna of Fig. 2,

Fig. 6 shows, a schematic frontal view of an example of embodiment of the planar antenna, according to the present invention, wherein two couples of metallic strips on the upper side of the antenna are used and wherein the ends corresponding to the metallized holes are in common, in order to achieve a double band behaviour,

Fig. 7 shows a schematic frontal view a further embodiment example of the planar antenna according to the present invention, wherein the third metallic strip on the upper side of the antenna has been removed and has been replaced with a coplanar line on the bottom side, thus allowing to move on the same side all the connections to the feeding cable.

[0018] With particular reference to the figures, the single-layer planar antenna, according to the present invention, comprises at least one radiating dipole, constituted by two thin metallic traces or strips 1 having any shape such as linear, spiral, meander or like, fed in a balanced way by means of a slot 4 etched on a small ground plane 2 placed on the bottom layer of a dielectric supporting substrate 8.

[0019] The metallic traces or strips 1 are generally printed on the upper layer of said single thin dielectric substrate 8, by using the well known etching techniques widely used in the printed circuit boards production. Anyway, other techniques for producing those metallic traces or strips can be used, as for example serigraphy technique with a conductive paint; all the techniques are included in the scope of the present patent.

[0020] The metallic traces or strips 1 have an end connected to the lower ground plane 2 by means of metallized holes ("via-holes") or conductive rivets 3, directly or through a lumped impedance. Optionally, the lumped impedances can be inserted in-series along the metallic traces or strips 1, typically near the via-holes 3. Said metallized holes 3 are disposed symmetrically with respect to the centre of the slot 4 and near its main edges in order to feed the two metallic traces or strips 1 in phase opposition, as required for a dipole antenna.

[0021] Centrally, with respect to the slot 4, is present another metallic trace or strip 5 that is connected, near said slot, to the ground plane 2 by another via-hole or conductive rivet 3 and is connected to the central conductor of a feeding coaxial cable, on the opposite side of the same metallized hole with reference to the slot 4. Optionally, it is possible to realize the feeding metallic trace or strip on the same side of the ground plane 2 using a coplanar technology, thus realizing a trace or strip 7 that is bound directly to the external edge of the slot 4, in its central position.

[0022] By appropriately varying the shape of the conductive metallic traces or strips 1 constituting the radiant element, it is also possible to insert further metallic traces or strips, i.e. two strips 6, also these strips fed in phase opposition in a balanced way. Such further metallic strips can be dimensioned in order to extend the working bandwidth of the antenna or to realize a second band centred on a frequency different from the first one. A typical example is a double band antenna, working respectively in the ISM (Industrial Scientific Medical) bands assigned to the keyless-entry system (434MHz and 868MHz).

[0023] Summarizing, while maintaining its fundamental characteristic of planarity together with an electromagnetic behaviour typical of a classical balanced fed dipole, the antenna can assume every shape such as rectangular, trapezoidal or generally polygonal, planar or curved, in order to conform, also aesthetically, with the requirements and bonds of the installation, for example, on a vehicle.

[0024] Independently of the shape of the metallic trace 1 constituting the radiating element and of the thin dielectric substrate 8 that uphold it, the antenna of the present invention shows a radiative behaviour completely similar to that of a classical dipole operating in the same working conditions.

[0025] Even though the present invention has been described and illustrated here with reference to some embodiments that are given only by way of non-limitative examples, it is clear that various changes to layouts, to details, to configurations, to orientations, to components and other combinations can be made by one skilled in the art in the light of the above-mentioned description.

[0026] It is therefore understood that the present invention is meant to include all the changes and variants falling within the spirit and the scope of the following claims.

Claims

1. A dielectric substrate single layer planar dipole antenna
   characterized in that it comprises:

   - a thin support substrate (8) of a dielectric material comprising an upper surface and a bottom surface;
   - a ground plane (2) placed on the bottom surface of said dielectric support substrate (8) and having dimensions smaller than those of said substrate (8);
   - a feeding comprising a slot (4) etched on said ground plain (2);
   - at least one radiating dipole consisting of two thin metallic strips (1) printed on the upper surface of said thin support substrate (8) fed in a balanced way by means of said slot (4); said metallic strips (1) having one end connected to the lower ground plane (2) by means of first metallized holes or conductive rivets (3) realized near the slot (4) and placed along the longer dimension of said slot, symmetrically with respect to the slot centre to feed the two metallic strips (1) in phase opposition;
   - a third thin metallic strip (5), placed centrally with the respect to said slot (4) and connected to the ground plane (2) by a second via-hole or conductive rivet (3), and
   - a feeding coaxial cable having inner conductor connected to said third thin metallic strip (5) and an outer conductor fixed to the ground.

2. The dielectric single layer planar antenna according to claim 1, **characterized in that** the metallic printed strips (1) have linear, spiral or meander shape.

3. The dielectric single layer planar antenna according to anyone of the previous claims, **characterized in that** the slot (4) is oriented and dimensioned to work as a unbalanced to balanced transformer (balun).

4. The dielectric single layer planar antenna according to anyone of the previous claims, **characterized in that** the non-radiating ends of the metallic strips (1), are connected to the ground plane (2) by means of metallized holes (via-holes) or conducting rivets (3) symmetrically disposed with respect to the centre of said slot (4) and near its main edges so that said strips (1) constituting the dipole arms are electrically in phase opposition placed close to the bigger sides of said slot (4), anti-symmetrically from an electric point of view (phase opposition), with respect to its centre.

5. The dielectric single layer planar antenna according to anyone of the previous claims, **characterized in that** the feeding strip is replaced by a coplanar waveguide etched on the opposite side of the planar dipole.

6. The dielectric single layer planar antenna according to anyone of the previous claims, **characterized in that** the metallized holes (via-holes) or conductive rivets (3), are replaced by lumped impedances to reduce the dimensions of the antenna and to increase its operative impedance bandwidth.

7. The dielectric simple layer planar antenna according to claim 6, **characterized in that** the lumped impedances are provided in series with the feeding strips.

8. The dielectric single layer planar antenna according to anyone of the previous claims, **characterized in that** the external conductor of the feeding coaxial cable is connected to a point of the patch surface where the amplitude of the radio frequency current is minimum.

9. The dielectric single layer planar antenna according

to anyone of the previous claims, **characterized in that** the metallic traces (1) on the upper side of the thin dielectric substrate (8), are two couples with the feeding ends, corresponding to the metallized holes, in common.

10. The dielectric single layer planar antenna according to anyone of the previous claims, **characterized in that** the planar antenna has dimensions even less than half a wavelength and a rectangular, trapezoidal or polygonal, planar or curved shape.

11. The dielectric single layer planar antenna according to anyone of the previous claims, **characterized in that** the metallic strips (1), are buried inside a multilayer constituted by at least two thin substrate layer of dielectric and/or magnetic material.

Fig.1

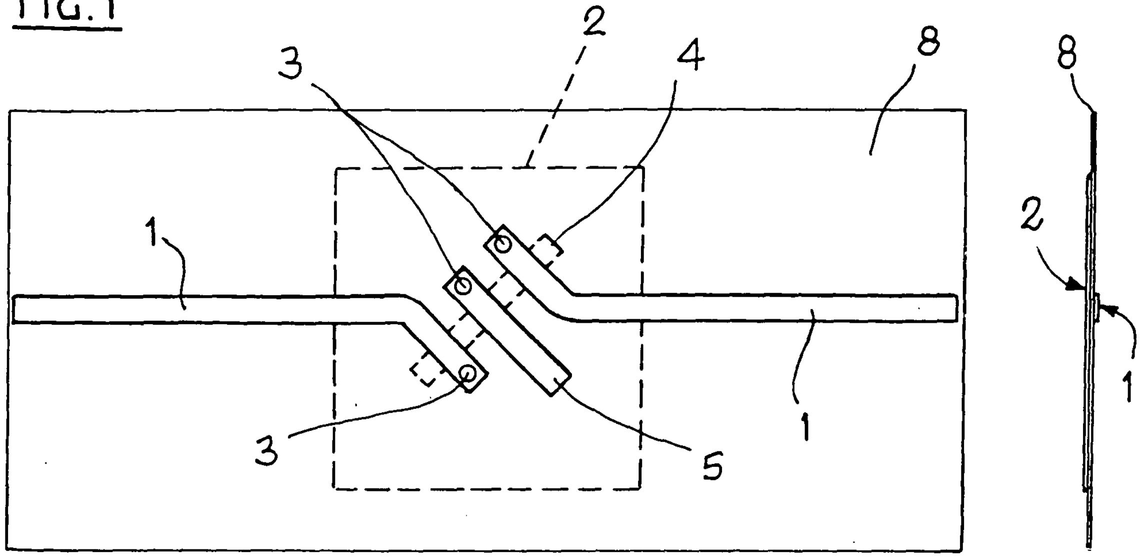
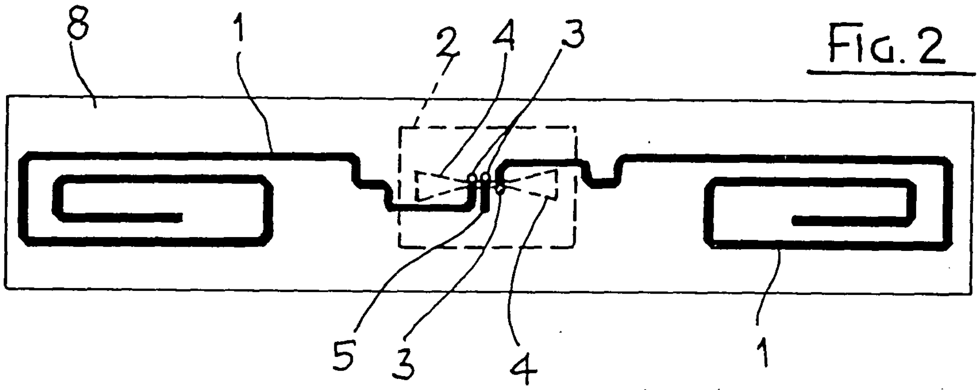


Fig.2



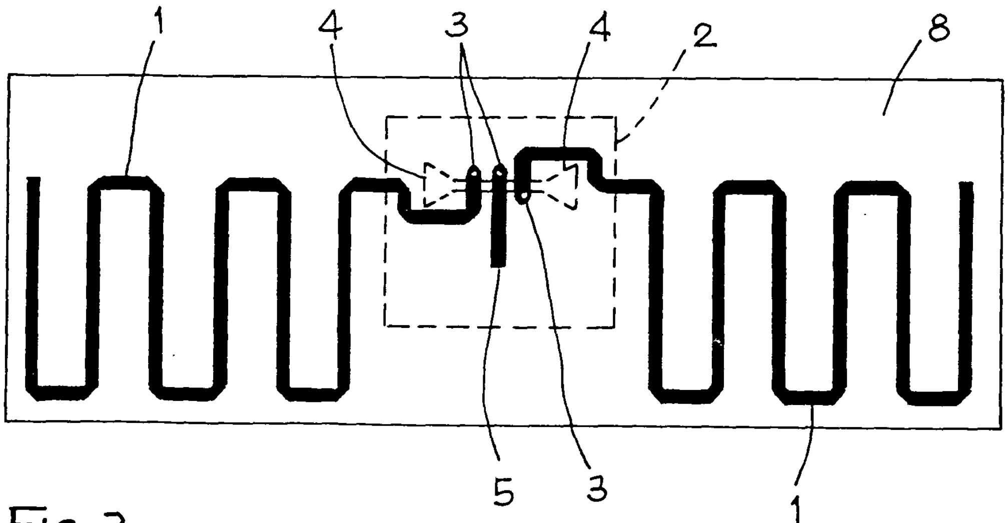


Fig.3

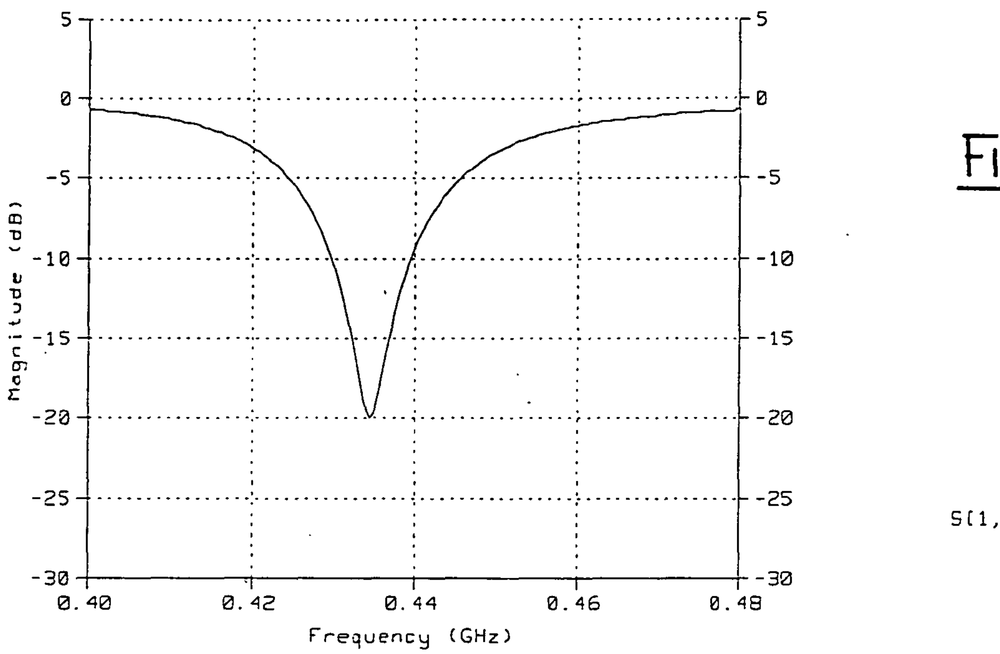

5
0
-5
-10
-15
-20
-25
-30
Magnitude (dB)
0.40
0.42
0.44
0.46
0.48
Frequency (GHz)
S(1,1)

FIG. 4

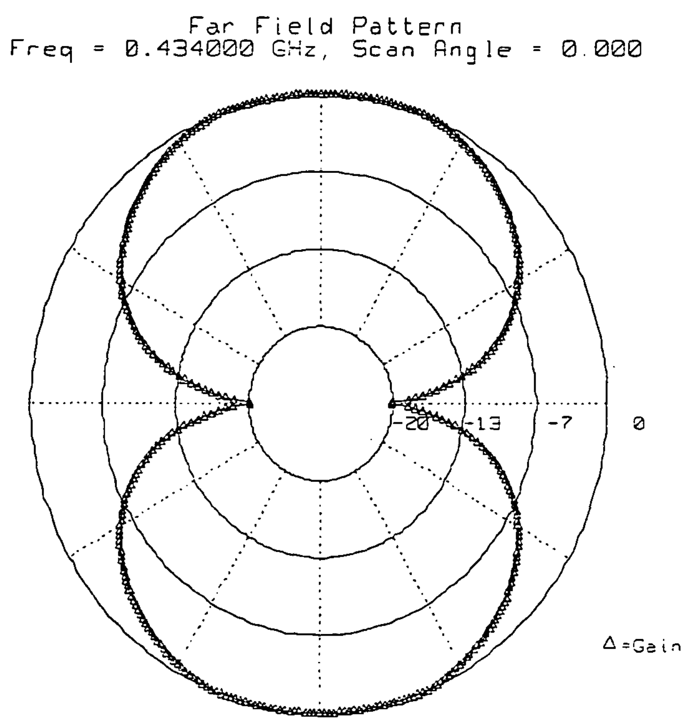

Far Field Pattern
Freq = 0.434000 GHz, Scan Angle = 0.000
-20
-13
-7
0
Δ=Gain

FIG. 5

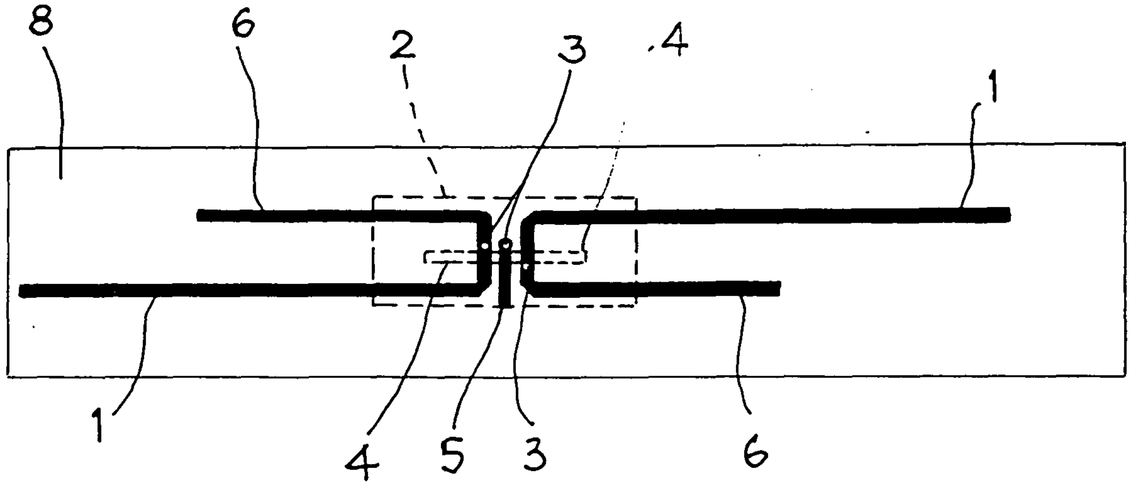


FIG. 6

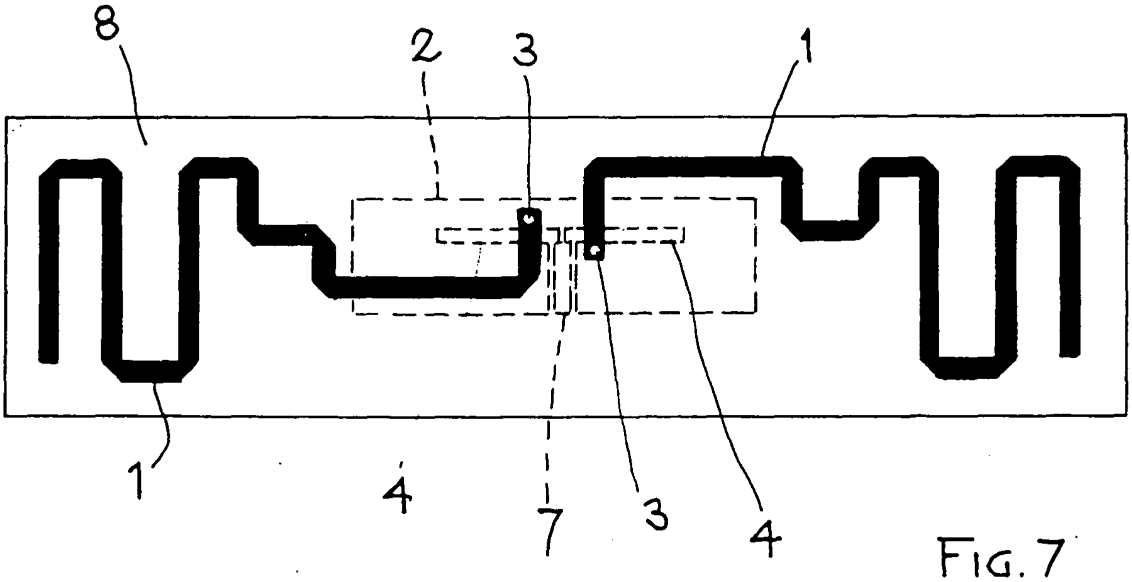


FIG. 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 01 1740

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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Y	MENZEL W ET AL: "A MICROSTRIP PATCH ANTENNA WITH COPLANAR FEED LINE" IEEE MICROWAVE AND GUIDED WAVE LETTERS, IEEE INC, NEW YORK, US, vol. 1, no. 11, 1 November 1991 (1991-11-01), pages 340-342, XP000230628 ISSN: 1051-8207 * figure 1 *	5	
A	DE 20 20 192 A (SIEMENS AG) 4 November 1971 (1971-11-04) * page 4 - page 6; figures 1-3 *	1	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	6 October 2004	Fredj, A

CATEGORY OF CITED DOCUMENTS

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