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(54) **Patch antenna having flexed ground plate**

Streifenantenne mit gebogener Grundplatte

Antenne à plaque avec plaque de terre courbé

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to an antenna, and more particularly, to a patch antenna typically used for mobile communications equipment.

2. Description of the Related Art

[0002] A patch antenna is light in its weight and has a thin cross section so as to be fixed easily to the roof or window of a car or the wall of a building. Thus, the patch antenna is preferred for wide radio applications including military purposes and commercial purposes, e.g., missiles, battlefield surveillance systems, telemetry systems, and aircraft or satellite communications. However, the patch antenna has a disadvantage in that it shows a narrow bandwidth, which typically ranges between 1 and 2%. Accordingly, it has been desired to develop an antenna which shows a wide bandwidth while maintaining the small size thereof.

[0003] Several approaches have been made to increase the bandwidth of the patch antenna but each attempt may introduce some new disadvantage. For example, increasing the height of a radiating plate with respect to a ground plate does increase the bandwidth but it also increases the excitation of surface waves and radiation from a feed line, both undesirable side effects. Another approach utilizes multiple patches which are stacked vertically at different levels with respect to a substrate. This approach directed to the multilayer patch configuration increases fabrication difficulties, and hence the cost of the antenna. Also, in both of the above approaches, the total thickness of the antenna is increased which reduces its utility in low profile operations. Yet another approach for increasing the bandwidth of the patch antenna involves the design of an impedance matching circuit for the patch antenna. In such an approach, the impedance matching circuit is designed so as to reduce the reactance component of the input impedance of the antenna. However, such an approach increases the antenna size and reduces the radiation efficiency.

SUMMARY OF THE INVENTION

[0004] The object of the present invention is to provide a patch antenna which shows a wide bandwidth and maintains a high radiation efficiency without increasing the size thereof.

[0005] The patch antenna for achieving the above object comprises a radiating plate, a ground plate, and means for feeding the radiating plate. The ground plate has a base plane and at least one vertical lip extended perpendicularly from the base plane to have an "L"-shaped or "U"-shaped cross section. In such a structure, a capacitive coupling is induced in the space between the radiating plate and the ground plate in the vicinity of the vertical lip, so that a wideband impedance matching and an increased forward-to-back ratio are obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The above objectives and advantages of the present invention will become more apparent by describing in detail preferred embodiments thereof with reference to the attached drawings in which:

FIG. 1 illustrates an embodiment of a patch antenna assembly according to the present invention;
FIG. 2 illustrates a cross-sectional view along line A-A of the patch antenna assembly of FIG. 1;
FIG. 3 is a graph showing the experimental measurement of a standing wave ratio for the patch antenna assembly of FIGS. 1 and 2;
FIG. 4 shows an E-plane radiation pattern for the patch antenna assembly of FIGS. 1 and 2;
FIG. 5 shows a H-plane radiation pattern for the patch antenna assembly of FIGS. 1 and 2;
FIG. 6 illustrates another embodiment of a patch antenna assembly according to the present invention; and
FIG. 7 illustrates a cross-sectional view along line B-B of the patch antenna of FIG. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0007] Referring to FIGS. 1 and 2, a patch antenna assembly in a preferred embodiment includes a patch antenna element and a housing for accommodating the patch antenna element. The patch antenna element includes a radiating plate 10, a ground plate 20, and a coaxial cable 30 for feeding signals to the radiating plate 10.

[0008] The housing consists of a top housing 50 and a bottom housing 60. The bottom housing 60 includes, on its top surface, an outer wall 62, protrusions 64 extending inwards from the outer wall 62 for supporting the ground plate 20, and fingers 66 for securing the radiating plate 10. Even though not being illustrated in the figures, four protrusions are formed on the inner surface of the wall of the top housing 50 and four recesses are formed correspondingly on the outer surface of the outer wall 62 of the bottom housing 60, so that the top housing 50 can be secured on the bottom housing 60. The housing is preferably made of plastic dielectric material having sufficient physical strength yet minimizing the reflection of the electromagnetic wave transmitted from or received by the patch antenna element.

[0009] The radiating plate 10 and the ground plate 20 may be made of conductive material such as a copper or aluminum sheet. The radiating plate 10 is rectangular-shaped and has a slit 12 having a "U"-shape and penetrating itself. The radiating plate 10 has a hole in its center for receiving a probe 39, i.e., the end of the center conductor of the coaxial cable 30, and holes near its corners for receiving the top end of the fingers 66. Meanwhile, the ground plate 20 has a base plane 22 and a vertical lip 24 extending perpendicularly from an edge of the base plane 22 so as to have an "L"-shaped cross section. Also, the ground plate 20 has holes so that the fingers 66 penetrate the plate.

[0010] The coaxial cable 30 includes a center conductor 32, an insulating layer 34 surrounding the center conductor 32, and an outer conductor 36 surrounding the insulating layer 34. The coaxial cable 30 is not sheathed and thus uninsulated in its outer surface so that the outer conductor 36 of the cable 30 directly contacts the ground plate 20. Meanwhile, a coaxial connector 38 for connecting the patch antenna assembly to an external circuit is disposed at an end of the coaxial cable 30. The other end of the cable 30 is flexed upwards by 90°. Here, the outer conductor 36 is stripped off at the vertical portion of the cable 30 flexed upwards.

[0011] The patch antenna assembly is assembled as follows. The ground plate 20 is disposed on the protrusions 64 while the fingers 66 being inserted into the holes of the ground plate 20. Next, the fitting portion of the coaxial connector 38 is disposed in a mating groove 62 of the bottom housing 60, and the outer conductor 36 of the coaxial cable 30 is fixed, preferably by soldering, on the ground plate 20. Subsequently, the radiating plate 10 is disposed on the top end of the fingers 66 while the probe 39 of the coaxial cable 30 being inserted to the center hole of the radiating plate 10. The probe 39 is soldered in the center hole of the radiating plate 10, so that the radiating plate 10 is electrically connected to the center conductor 32 of the coaxial cable 30 while being secured in parallel with the ground plate 20. Finally, the top housing 50 is secured on the bottom housing 60 by engaging four not shown protrusions on the inner surface of the wall of the top housing 50 and four not shown recesses on the outer surface of the bottom housing 60.

[0012] In the patch antenna assembly of FIGS. 1 and 2, the radiating plate 10 is parallel to, but separated from the ground plate 20 by the coaxial cable 30 and the fingers 66. Also, the outer conductor 36 of the coaxial cable 30 terminates on the ground plate 20 and the center conductor 32 terminates on the radiating plate 10. Thus, the radiating plate 10 is fed from the rear using the center conductor 32 of the coaxial cable 30.

[0013] Meanwhile, the vertical lip 24 extending from the edge of the base plane 22 changes the electromagnetic field distribution in the space between the radiating plate 10 and the ground plate 20 in the vicinity of the vertical lip 24. Such a change in the electromagnetic field distribution increases a distributed capacitance between the radiating plate 10 and the ground plate 20. The increased distributed capacitance compensates for the inductive reactance induced in the coaxial cable 30, which allows a wideband impedance matching and expands the beam width of the main lobe of the radiated wave.

[0014] Also, the magnitude of the induced capacitance may be adjusted by varying the height of the vertical lip 24 and the distance between the edge of the radiating plate 10 and the vertical lip 24. That is, if the distance between the edge of the radiating plate 10 and the vertical lip 24 is getting smaller, the induced capacitance is getting larger and the resonance frequency moves toward a lower band. Thus, it is possible to reduce the dimension of the radiating plate 10 and the overall size of the antenna. For example, the length of the radiating plate 10 may be determined to be smaller than $\lambda/2$, where λ is the operating wavelength of the antenna assembly.

[0015] On the other hand, it is well known in the art that a larger ground plate is preferable in a directional antenna in order to enhance the front-to-back ratio of the antenna. The larger ground plate, however, is disadvantageous in that it also increases the dimension and weight of the antenna. In the patch antenna according to the present embodiment, the vertical lip 24 of the ground plate 20 reduces the portion of the wave which radiates backward from the radiating plate 10. Accordingly, it is possible to enhance the front-to-back ratio while reducing the horizontal dimension of the ground plate 20 compared with those of prior art.

[0016] In addition, the height of the vertical lip 24 and the distance between the radiating plate 10 and the vertical lip 24 may be determined in such a manner that a desired beam width is obtained.

[0017] FIG. 3 shows the experimental measurement of a standing wave ratio for the patch antenna assembly of FIGS. 1 and 2. Standing wave ratios were calculated based on scattering (S) parameters measured at the input terminal of the coaxial connector 40. Standing wave ratios at 824, 849, 869 and 894 MHz were 1.23, 1.15, 1.26, and 1.18, respectively. As shown in FIG. 3, the standing wave ratio for the patch antenna assembly of FIGS. 1 and 2 maintains low value over a wide band extending more than 100 MHz.

[0018] FIGS. 4 and 5 show E-plane and H-plane radiation patterns, respectively, at 849 MHz for the patch antenna assembly of FIGS. 1 and 2. The antenna radiation patterns show that most of the power is radiated to the front direction of the radiating plate and reflect the high front-to-back ratio of the patch antenna according to the present invention. As shown in FIGS. 4 and 5, the maximum E-plane gain is 7.54 dB and the maximum H-plane gain is 7.80 dB. The beam width at 3 dB half point is 82.32 degrees in the E-plane and 84.05 degrees in the H-plane.

[0019] FIGS. 6 and 7 illustrate another embodiment of a patch antenna assembly according to the present invention. In the patch antenna assembly shown in FIGS. 6 and 7, the ground plate 70 is flexed upwards at two edges opposite to each other so as to have a "U"-shaped cross section. Accordingly, the ground plate 70 includes a base plane 72 and a first vertical lip 74 extending perpendicularly from an edge of the base plane 72, and a second vertical lip 76 extending perpendicularly from another edge of the base plane 72 and being parallel to the first vertical lip 74. The other features of the patch antenna assembly of FIGS. 6 and 7 are similar to those of the patch antenna assembly of FIGS. 1 and 2, and thus detailed description thereof will be omitted.

[0020] Those of ordinary skill in the art will appreciate that many obvious modifications can be made to the invention without departing from its spirit or essential characteristics. For example, even though any dielectric material other than air is not filled between the radiating plate and the ground plate in the preferred embodiments, a dielectric layer such as a Teflon fiberglass layer and a ceramic layer may be inserted between the radiating plate and the ground plate alternatively.

Claims

1. A patch antenna comprising:

a radiating plate (10);
a ground plate (20) comprising a base plane (22) having a first and a second edges and being parallel to but separated from said radiating plate (10), and a first vertical lip (24) extending perpendicularly from said first edge of said base plane (22); and
means (30) for feeding said radiating plate (10).

2. The patch antenna as claimed in claim 1, wherein said base plane (22) of said ground plate (20) has a rectangular shape.

3. The patch antenna as claimed in claim 1, wherein said radiating plate (10) has a slit (12) having a "U"-shape.

4. The patch antenna as claimed in claim 1, further comprising:

means (66) for supporting said radiating plate (10) so that said radiating plate (10) is maintained rigidly being parallel to but separated from said ground plate (20).

5. The patch antenna as claimed in claim 4, wherein said patch antenna is installed in a housing having an inner bottom surface and at least one fingers fixed on the inner bottom surface, said supporting means (66) being said at least one fingers.

6. The patch antenna as claimed in claim 1, further comprising:

an dielectric layer, disposed between said radiating plate (10) and said ground plate (20), said dielectric layer made of a dielectric material selected from the group consisting of ceramic and Teflon fiberglass.

7. The patch antenna as claimed in claim 1, wherein said radiating plate (10) is separated from said ground plate (20) by a predetermined distance such that the distributed capacitance between the radiating plate (10) and the ground plate (29) at least partially compensates for the inductive reactance induced in the antenna, so as to perform a wideband impedance matching and coincide a resonant frequency of said patch antenna substantially to an operating frequency.

8. The patch antenna as claimed in claim 1, wherein said ground plate (20) further comprises a second vertical lip (76) extending perpendicularly from said second edge of said base plane (22), said second vertical lip (76) being parallel to said first vertical lip (24).

Patentansprüche

1. Streifenantenne mit:

einer Abstrahlfläche (10) ;
einer Grundfläche (20), welche umfaßt: eine Basisebene (22), welche eine erste und eine zweite Kante hat, und parallel zu der Abstrahlfläche (10) verläuft, jedoch von dieser getrennt ist, und einen ersten vertikalen Rand (24), welcher sich senkrecht von der ersten Kante der Basisebene (22) aus erstreckt; und
Mittel (30) zur Beschickung/Versorgung der Abstrahlfläche (10).

2. Streifenantenne nach Anspruch 1, bei welcher die Basisebene (22) der Grundfläche (20) eine rechteckige Form hat.

3. Streifenantenne nach Anspruch 1, bei welcher die Abstrahlfläche (10) einen Schlitz (12) in einer "U"-Form hat.

4. Streifenantenne nach Anspruch 1, zusätzlich umfassend:

Mittel (66) zum Halten der Abstrahlfläche (10), so daß die Abstrahlfläche (10) in fester Position parallel zur Grundfläche (20), jedoch von dieser getrennt, gehalten wird.

5. Streifenantenne nach Anspruch 4, bei welcher die Streifenantenne in ein Gehäuse eingebaut ist, welches eine innere Bodenoberfläche und mindestens einen auf der inneren Bodenoberfläche fixierten Finger hat, wobei das Haltemittel (66) der mindestens eine Finger ist.

6. Streifenantenne nach Anspruch 1, zusätzlich umfassend:

eine zwischen der Abstrahlfläche (10) und der Grundfläche (20) angeordnete dielektrische Schicht, wobei die dielektrische Schicht aus dielektrischem Material hergestellt ist, das aus folgender Materialgruppe: Keramik und Teflon-Fiberglas ausgewählt ist.

7. Streifenantenne nach Anspruch 1, bei welcher die Abstrahlfläche (10) mit einem vorbestimmten Abstand von der Grundfläche (20) separiert ist, so daß die verteilte Kapazität zwischen der Abstrahlfläche (10) und der Grundfläche (20) zumindest teilweise den in die Antenne induzierten Blindwiderstand ausgleicht, um somit eine Breitband Impedanzanpassung zu realisieren, und eine Resonanzfrequenz der Streifenantenne im wesentlichen mit einer Betriebsfrequenz übereinstimmen zu lassen.

8. Streifenantenne nach Anspruch 1, bei welcher die Grundfläche (20) ferner einen zweiten vertikalen Rand (76) umfaßt, welcher sich senkrecht von der zweiten Kante der Basisebene (22) aus erstreckt, wobei der zweite vertikale Rand (76) parallel zum ersten vertikalen Rand (24) verläuft.

Revendications

1. Antenne à plaque comprenant :

une plaque rayonnante (10) ;
une plaque de terre (20) comprenant un plan de base (22) doté d'un premier et d'un second bords et étant parallèles à, mais séparés de ladite plaque rayonnante (10), et une première lèvre verticale (24) qui s'étend perpendiculairement à partir dudit premier bord dudit plan de base (22) ; et
des moyens (30) pour alimenter ladite plaque rayonnante (10).

2. Antenne à plaque selon la revendication 1, dans laquelle ledit plan de base (22) de ladite plaque de terre (20) a une forme rectangulaire.

3. Antenne à plaque selon la revendication 1, dans laquelle ladite plaque rayonnante (10) est dotée d'une fente (12) en forme de U.

4. Antenne à plaque selon la revendication 1, comprenant en outre des moyens (68) pour supporter ladite plaque rayonnante (10) de sorte que ladite plaque rayonnante (10) est maintenue rigidement en étant parallèle à, mais séparée de ladite plaque de terre (20).

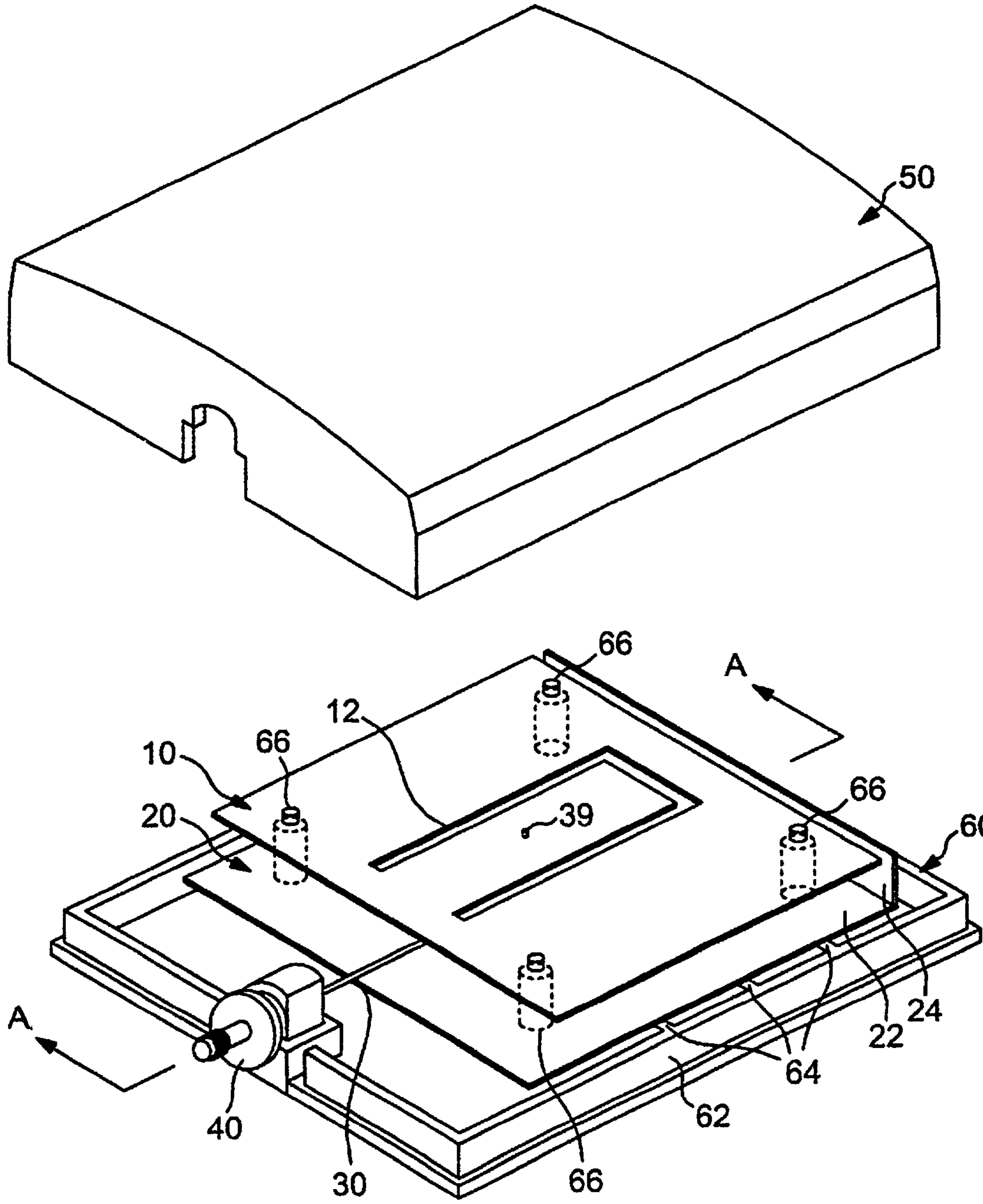
5. Antenne à plaque selon la revendication 4, dans laquelle ladite antenne à plaque est installée dans un logement doté d'une surface de fond interne et au moins d'un doigt fixé sur la surface de fond interne, lesdits moyens de support (66) étant lesdits au moins un doigt.

6. Antenne à plaque selon la revendication 1, comprenant en outre une couche diélectrique disposée entre ladite plaque rayonnante (10) et ladite plaque de terre (20), ladite couche diélectrique est réalisée avec un matériau diélectrique choisi dans le groupe comprenant la céramique et la fibre de verre Teflon.

7. Antenne à plaque selon la revendication 1, dans laquelle ladite plaque rayonnante (10) est séparée de ladite plaque de terre (20) par une distance prédéterminée de sorte que la capacité répartie entre la plaque rayonnante (10) et la plaque de terre (29) compense au moins partiellement la réactance inductive induite dans l'antenne, afin de réaliser l'impédance à large bande qui correspond et qui coïncide avec une fréquence résonante de ladite antenne à plaque sensiblement à une fréquence de fonctionnement.

8. Antenne à plaque selon la revendication 1, dans laquelle ladite plaque de terre (20) comprend en outre une seconde lèvre verticale (76) qui s'étend perpendiculairement audit second bord dudit plan de base (22), ladite seconde lèvre verticale (76) étant parallèle à ladite première lèvre verticale (24).

FIG. 1



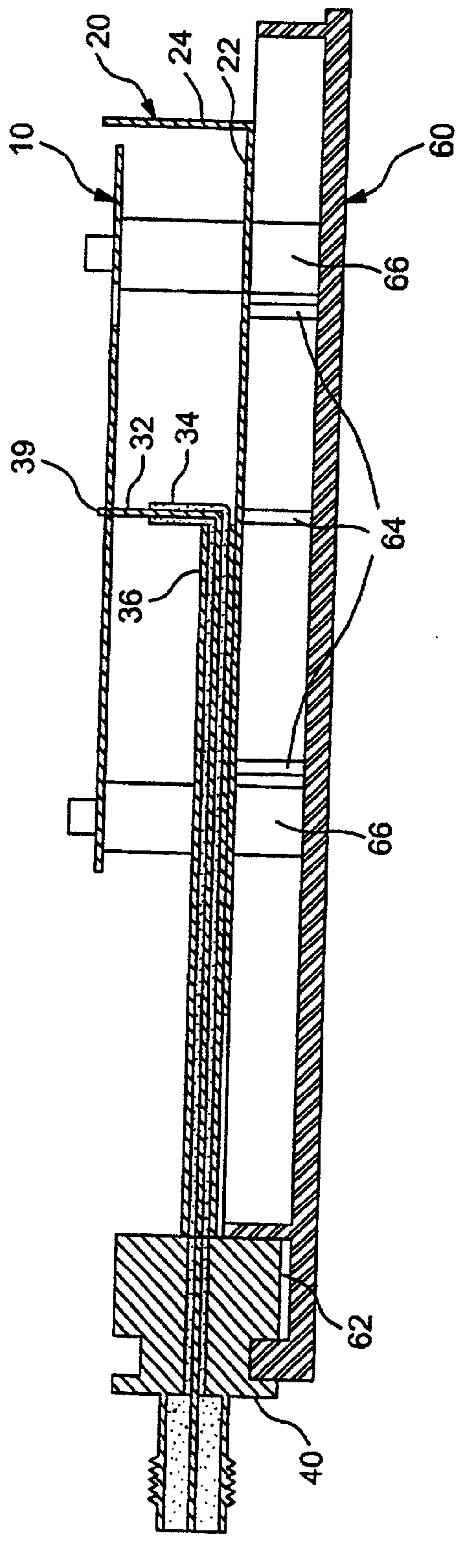


FIG. 2

FIG. 3

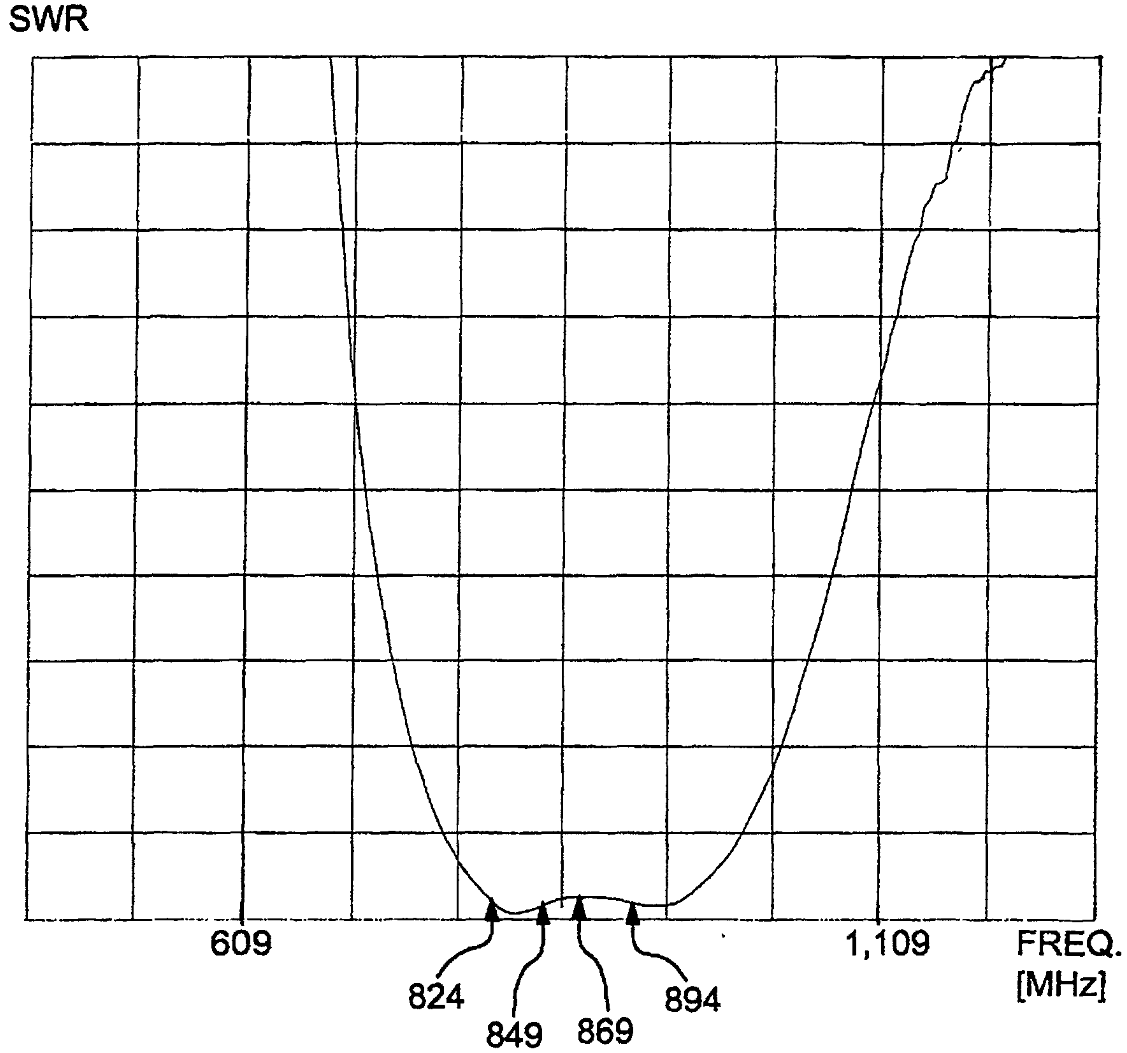
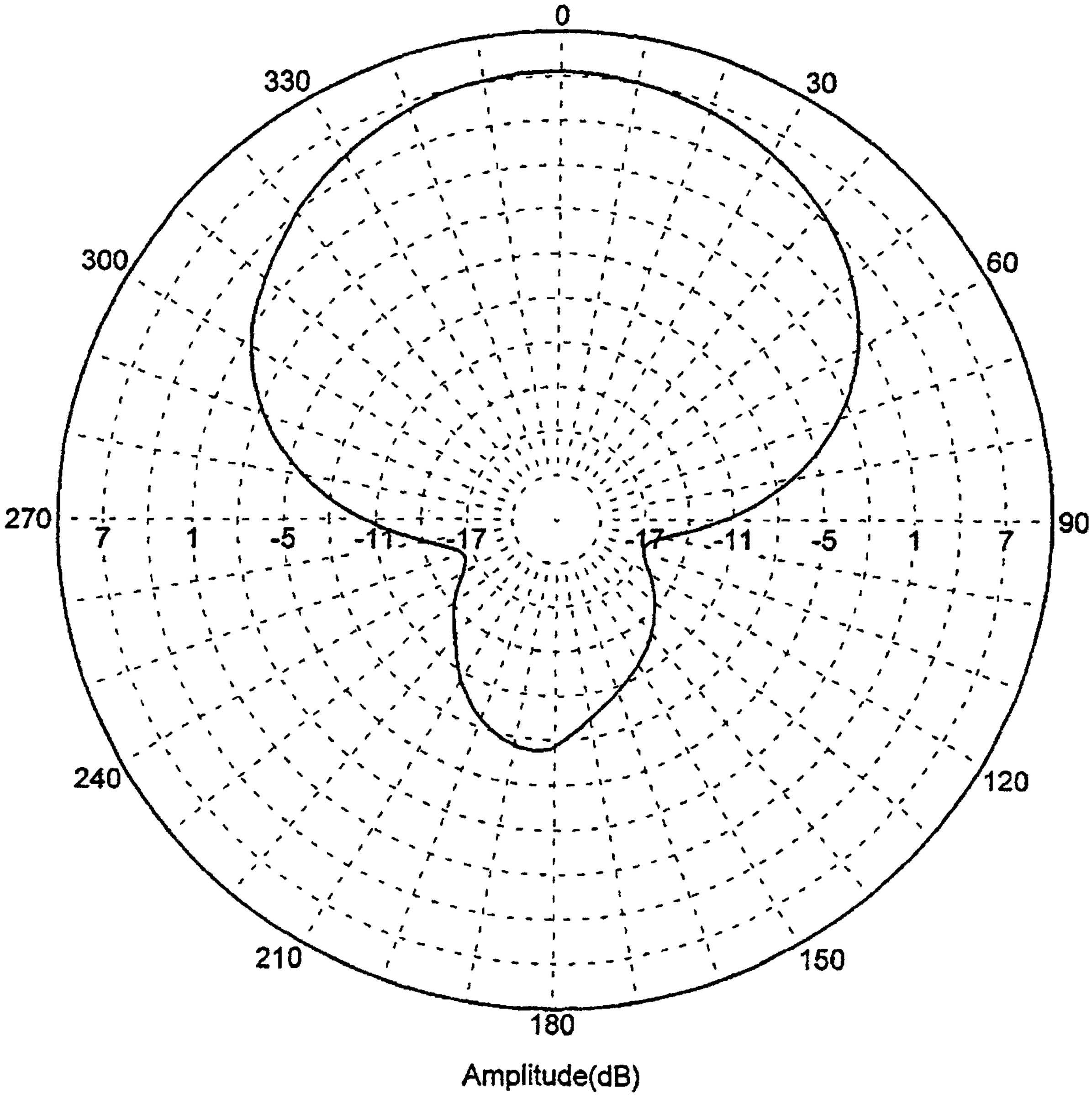


FIG. 4


0
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60
90
120
150
180
210
240
270
300
330
7
1
-5
-11
-17
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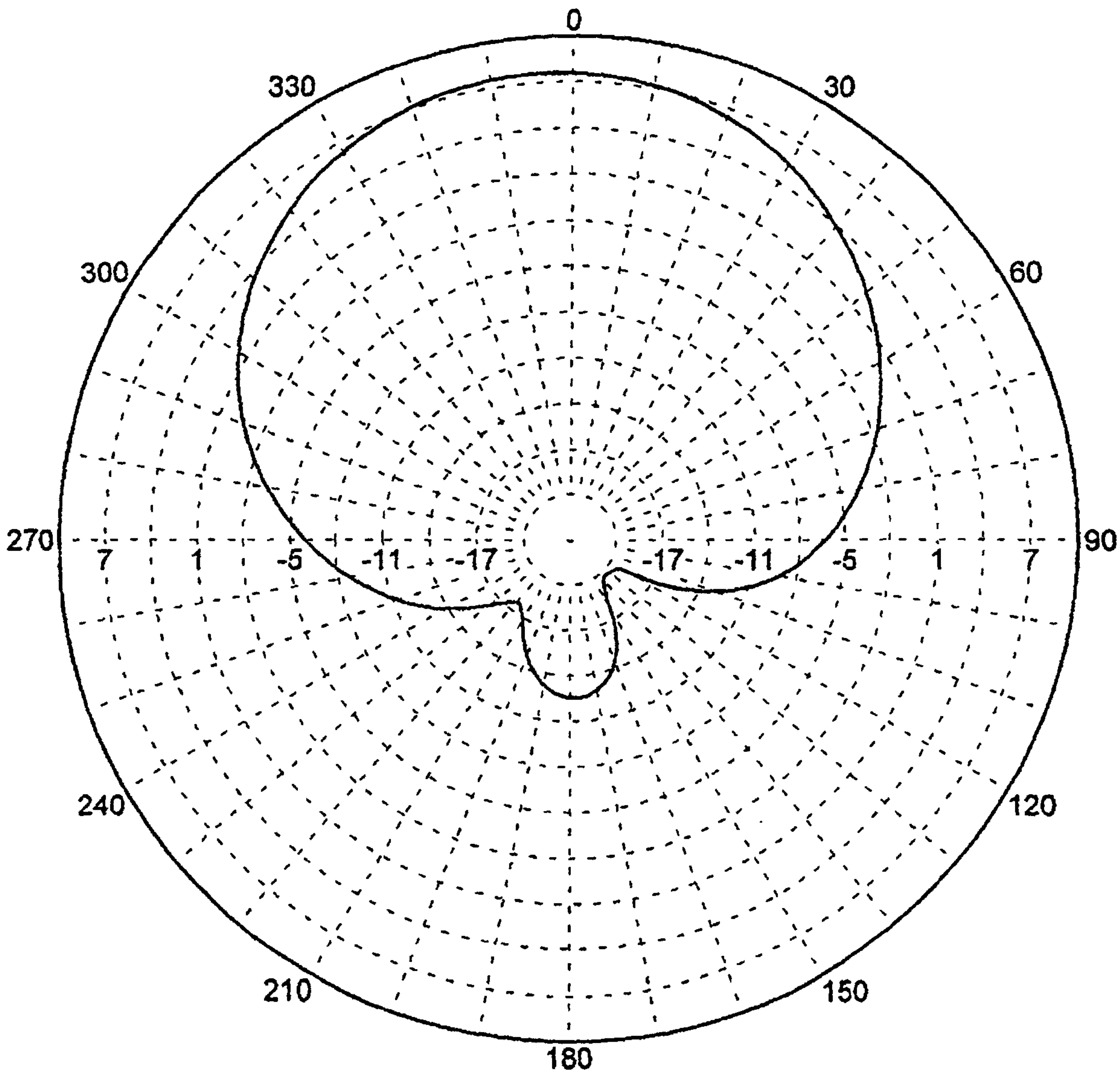
-5
1
7
Amplitude(dB)

FIG. 5



Amplitude(dB)

FIG. 6

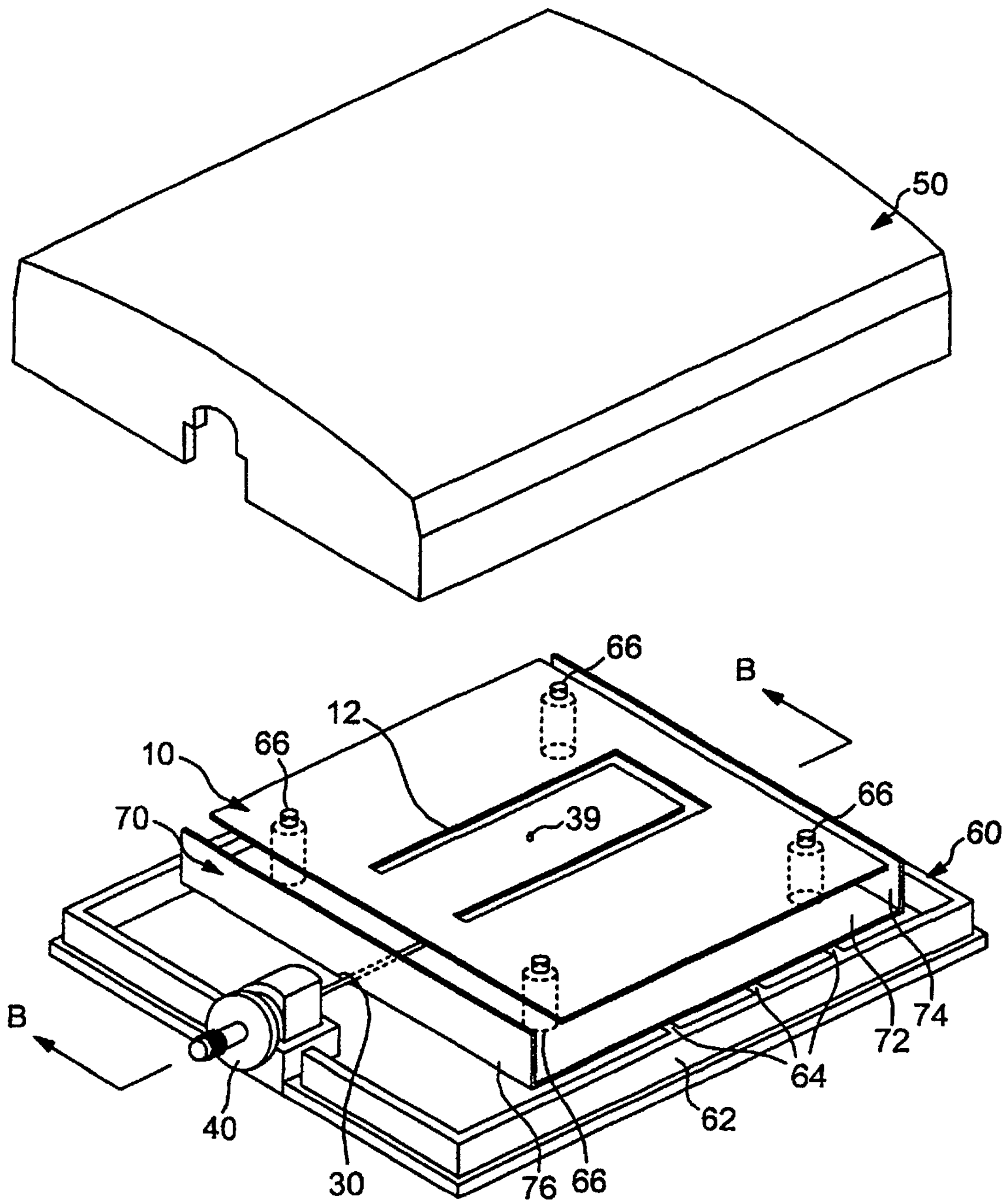


FIG. 7