(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 796 212 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
13.06.2007 Bulletin 2007/24

(51) Int Cl.:
H01Q 9/04 *(2006.01)* ***H01Q 1/38*** *(2006.01)*

(21) Application number: **06025245.9**

(22) Date of filing: **06.12.2006**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK YU

(30) Priority: **08.12.2005 JP 2005355070**

(71) Applicant: **ALPS ELECTRIC CO., LTD.**
Tokyo 145-8501 (JP)

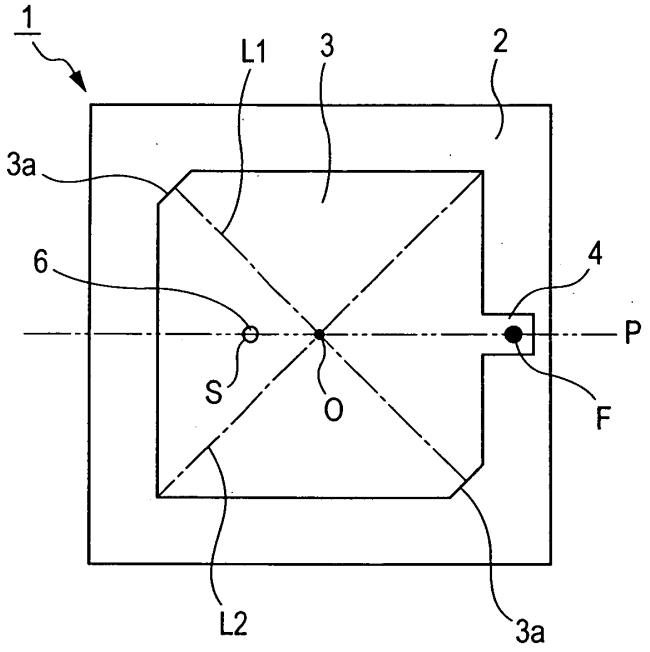
(72) Inventor: **Shikata, Masaru**
Ota-ku
Tokyo 145-8501 (JP)

(74) Representative: **Klunker . Schmitt-Nilson . Hirsch**
Winzererstrasse 106
80797 München (DE)

(54) Patch antenna

(57) A patch antenna is disposed such that a radiating conductor loaded with a degeneracy splitting element opposes a ground conductor with a predetermined distance therebetween. A feeding conductor extends outward from an edge of the radiating conductor, and a tip of the feeding conductor functions as a feeding section. A short-circuit point is set in a region opposite to the feeding conductor in the radiating conductor, and the short-circuit point S is electrically connected to the ground conductor via a short-circuit conductor. For instance, the radiating conductor and the feeding conductor are disposed on one surface of the dielectric substrate, whereas the ground conductor is disposed on the other surface of the dielectric substrate, and the short-circuit conductor is provided in a through hole provided in the dielectric substrate. A short-circuit point connected to the short-circuit conductor in the radiating conductor may be set on an extension of a line P connecting the center of the radiating conductor and the feeding conductor.

FIG. 1



EP 1 796 212 A1

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a planar-feed-type patch antenna capable of feeding electricity to a radiating conductor in the same plane as the radiating conductor is disposed, and more particularly, it relates to a patch antenna operated as a circularly polarized antenna.

2. Description of the Related Art

[0002] A planar-feed-type patch antenna typically has a radiating conductor and an impedance matching circuit disposed on one surface of a dielectric substrate, and a ground conductor disposed on the other surface of the dielectric substrate in at least a region opposing the radiating conductor. A feed signal is applied to a certain position at an edge of the radiating conductor via the impedance matching circuit. However, since the impedance matching circuit is provided in the configuration, the patch antenna may be consequently of large size.

[0003] Heretofore, there is known a patch antenna in which a pair of slits are formed at edges of the radiating conductor, and a feeding section is provided within a band-like region interposed between the slits, so that electricity may be fed directly to the feeding section (for example, see Japanese Unexamined Patent Application Publication No. 5-259731, pages 2 to 4, Fig. 2). The above-mentioned known patch antenna is used for linear polarization, and impedance may be adjusted by properly determining the depth of the pair of slits sandwiching the feeding section. Accordingly, additional provision of the impedance matching circuit is not necessary, thereby promoting reduction in size of the patch antenna.

[0004] As described in the related art, the method of adjusting the impedance according to the formation of the slits at the edges of the radiating conductor would not cause any problem when it is applied to a linearly polarized antenna. However, when the method is applied to a circularly polarized antenna, it may be difficult to obtain a good axial ratio characteristic, inevitably causing deterioration in radiation gain. In particular, when the known method is applied to the circularly polarized antenna, it is necessary to form slits not only in the vicinity of the feeding section of the radiating conductor for the impedance adjustment, but also at other edges extending in a direction orthogonal to the former slits, for compensation. However, when the number and variety of the slits formed in the radiating conductor increase, it may be difficult to adjust resonance characteristics appropriately for both of the two excitation modes which are electrically and spatially orthogonal to each other, and accordingly, the axial ratio characteristic of the circular polarization may be deteriorated.

SUMMARY OF THE INVENTION

[0005] In light of the above-described circumstances of the related art, an object of the present invention is to provide a planar-feed-type patch antenna for circular polarization providing a good axial ratio characteristic and being of reduced size.

[0006] To attain the above-described object, a patch antenna according to an aspect of the present invention includes: a ground conductor; a radiating conductor which is loaded with a degeneracy splitting element and disposed so as to oppose the ground conductor with a predetermined distance therebetween; a feeding conductor which extends from the radiating conductor outward in the radial direction of the radiating conductor so that a tip of the feeding conductor functions as a feeding section; and a short-circuit conductor which is disposed to connect the radiating conductor to the ground conductor at a predetermined position in a region of the radiating conductor opposite to the feeding conductor.

[0007] With the radiating conductor of the patch antenna configured as described above, a 0 Ω impedance point, at which voltage becomes zero in feeding, is provided at a location deviated from the center of the radiating conductor and at which the radiating conductor is connected to the short-circuit conductor, and distributions of voltage and current would be largely different from those in a case where the short-circuit conductor is not provided. Accordingly, it is possible to set the feeding section with an impedance of 50 Ω in the feeding conductor extending outward from the radiating conductor. Owing to this, feeding with achievement of impedance matching is available if a coaxial cable or the like with a characteristic impedance of 50 Ω is connected to the feeding section disposed in the feeding conductor, and the patch antenna may be of reduced size even though the slits are not formed in the radiating conductor. In addition, since it is not necessary to form the slits in the radiating conductor, it is easy to design the radiating conductor to be of a shape having a good axial ratio characteristic.

[0008] In the above-described configuration, the number of the short-circuit conductors is appropriately determined on the basis of the location on the radiating conductor at which the short-circuit conductor is connected. For example, when the short-circuit conductor is connected to the radiating conductor at the predetermined position disposed on an extension of a line connecting the center of the radiating conductor and the feeding conductor, the short-circuit conductor is required to be provided only at this one location, thereby facilitating manufacturing. Alternatively, when a first short-circuit conductor is connected to the radiating conductor at a predetermined position on a first line connecting the center of the radiating conductor and the degeneracy splitting element, and a second short-circuit conductor is connected to the radiating conductor at a predetermined position on a second line orthogonal to the first line and passing

through the center of the radiating conductor, the short-circuit conductors are provided at these two locations, and accordingly, it becomes possible to adjust the resonance characteristics appropriately for both of the two excitation modes which are electrically and spatially orthogonal to each other, thereby further enhancing improvement of the axial ratio characteristic.

[0009] In addition, in the above-described configuration, the radiating conductor and the feeding conductor may be disposed on one surface of a dielectric substrate, whereas the ground conductor may be disposed on the other surface of the dielectric substrate, and the short-circuit conductor is provided in a through hole penetrating through the dielectric substrate. This configuration is preferable because it may provide a patch antenna having a simple structure and promoting mass production.

[0010] With the patch antenna according to the present invention, it is possible to set the feeding section with the impedance of 50 Ω in the feeding conductor extending outward in the radial direction from the radiating conductor, by connecting the short-circuit conductor to the radiating conductor at the predetermined position deviated from the center of the radiating conductor, in the radiating conductor loaded with the degeneracy splitting element. Accordingly, there may be provided a patch antenna that is preferable for achieving reduction in size and does not need the impedance matching circuit even though the slits are not formed in the radiating conductor. In addition, since it is not necessary to form the slits in the radiating conductor, the radiating conductor may be easily designed to be of a shape having a good axial ratio characteristic, thereby facilitating manufacturing of a patch antenna for circular polarization which may secure a necessary amount of radiation gain.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Fig. 1 is a plan view showing a patch antenna according to a first embodiment of the present invention;

Fig. 2 is a cross sectional view of the patch antenna;

Fig. 3 is a characteristic diagram showing radiation gain of the patch antenna in an elevation angle direction; and

Fig. 4 is a plan view showing a patch antenna according to a second embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] For describing an embodiment of the present invention with reference to the attached drawings, Fig. 1 is a plan view showing a patch antenna according to a first embodiment of the present invention, Fig. 2 is a cross sectional view of the patch antenna, and Fig. 3 is a characteristic diagram showing radiation gain of the patch antenna in an elevation angle direction.

[0013] A patch antenna 1 shown in these drawings generally includes a dielectric substrate 2, a radiating conductor 3 and a feeding conductor 4 disposed on the top surface of the dielectric substrate 2, a ground conductor 5 disposed on the bottom surface of the dielectric substrate 2, and a short-circuit conductor 6 provided in a through hole 2a penetrating through the dielectric substrate 2. The radiating conductor 3 is patterned to be substantially square-shaped, and two corners corresponding to either end of one diagonal L1 of the square are cut so as to remove triangular portions and loaded with degeneracy splitting elements 3a. The feeding conductor 4 extends outward in the radial direction of the radiating conductor 3 to be projected from a position in the middle of an edge of the radiating conductor 3 by a certain distance, and a tip of the feeding conductor 4 functions as a feeding section F, whereby a planar-feed-type patch antenna is configured. The ground conductor 5 is disposed substantially over the bottom surface of the dielectric substrate 2, and the radiating conductor 3 opposes the ground conductor 5 with the dielectric substrate 2 interposed therebetween. This provides a structure of a dielectric patch antenna. An upper end of the short-circuit conductor 6 is connected to the radiating conductor 3 at a predetermined position thereof, and a lower end thereof is connected to the ground conductor 5. Thus, a short-circuit point S that is a connection location on the radiating conductor 3 connected to the short-circuit conductor 6 is electrically connected to the ground conductor 5 via the short-circuit conductor 6. The short-circuit point S is set on an extension of a line P connecting the center O of the radiating conductor 3 and the feeding conductor 4 (feeding section F), namely, it is set at a position deviated toward the side opposite the feeding conductor 4 by a predetermined distance from the center O of the radiating conductor 3.

[0014] The patch antenna 1 is designed such that a length of the one diagonal L1 of the radiating conductor 3 (a distance between the pair of degeneracy splitting elements 3a and 3a) is shorter than a length of the other diagonal L2 by a certain distance, and a phase difference of about 90 degrees is generated between an excitation mode along the diagonal L1 and an excitation mode along the diagonal L2. Accordingly, the patch antenna 1 is operated as a one-point feed type, circularly polarized antenna, by applying a feed signal at a predetermined frequency to the feeding section F. However, since the radiating conductor 3 has a 0 Ω impedance point, at which voltage becomes zero in feeding, provided at the connection location (short-circuit point S) at which the radiating conductor 3 is connected to the short-circuit conductor 6 and the connection location is deviated from the center O of the radiating conductor 3, distributions of voltage and current of the radiating conductor 3 would be largely different from those in a case where the short-circuit conductor 6 is not provided. For example, a current distribution curve of the radiating conductor 3 extending

along the left-right direction shown in Fig. 2 reaches the maximum value in the vicinity of the short-circuit point S, but varies relatively gently. Thus, the patch antenna 1 may have the feeding section F with the impedance of 50 Ω in the feeding conductor 4 extending outward from the radiating conductor 3. Owing to this, feeding with achievement of impedance matching is available if a coaxial cable or the like with a characteristic impedance of 50 Ω is connected to the feeding section F.

[0015] The patch antenna 1 according to the present embodiment may set the feeding section F with the impedance of 50 Ω in the feeding conductor 4 extending outward in the radial direction from the radiating conductor 3. Consequently, the patch antenna may be reduced in size since the impedance matching circuit is not necessary even though the slits are not formed in the radiating conductor 3. In addition, since it is not necessary to form the slits in the radiating conductor 3, the radiating conductor 3 may be easily designed to be of a shape having a good axial ratio characteristic, thereby easily securing a necessary amount of radiation gain. For example, a gain at the elevation angle of 90 degrees is as good as about 2.4 dBic. Further, the short-circuit conductor 6 is only required to be provided at one location of the dielectric substrate 2 in the through hole 2a, thereby simplifying the structure, facilitating manufacturing, and promoting easy mass production.

[0016] Fig. 4 is a plan view showing a patch antenna according to a second embodiment. Like numbers refer to like components shown in Fig. 1, and the description thereof is omitted.

[0017] A patch antenna 10 shown in Fig. 4 is different from the one described in the first embodiment in that two short-circuit conductors are connected to the radiating conductor 3 at two locations. In particular, with the patch antenna 10, a short-circuit point S1 disposed on the one diagonal L1 of the radiating conductor 3 is connected to an upper end of a first short-circuit conductor 11, and a short-circuit point S2 disposed on the other diagonal L2 is connected to an upper end of a second short-circuit conductor 12. Both lower ends of the short-circuit conductors 11 and 12 are connected to the ground conductor (not shown) at the bottom surface of the dielectric substrate 2. Since the short-circuit point S1 and the short-circuit point S2 are separately provided at the two locations in the radiating conductor 3, it becomes possible to adjust the resonance characteristics appropriately for both of the two excitation modes which are electrically and spatially orthogonal to each other, thereby further enhancing improvement of the axial ratio characteristic.

Claims

1. A patch antenna comprising:

   a ground conductor;

   a radiating conductor which is loaded with a degeneracy splitting element and disposed so as to oppose the ground conductor with a predetermined distance therebetween;

   a feeding conductor which extends from the radiating conductor outward in the radial direction of the radiating conductor so that a tip of the feeding conductor functions as a feeding section; and

   a short-circuit conductor which is disposed to connect the radiating conductor to the ground conductor at a predetermined position in a region of the radiating conductor opposite to the feeding conductor.

2. The patch antenna according to Claim 1, wherein the short-circuit conductor is connected to the radiating conductor at the predetermined position disposed on an extension of a line connecting the center of the radiating conductor and the feeding conductor.

3. The patch antenna according to Claim 1, wherein a first short-circuit conductor is connected to the radiating conductor at a predetermined position on a first line connecting the center of the radiating conductor and the degeneracy splitting element, and a second short-circuit conductor is connected to the radiating conductor at a predetermined position on a second line orthogonal to the first line and passing through the center of the radiating conductor.

4. The patch antenna according to any one of Claims 1 through 3, wherein the radiating conductor and the feeding conductor are disposed on one surface of a dielectric substrate, whereas the ground conductor is disposed on the other surface of the dielectric substrate, and the short-circuit conductor is provided in a through hole penetrating through the dielectric substrate.

FIG. 1

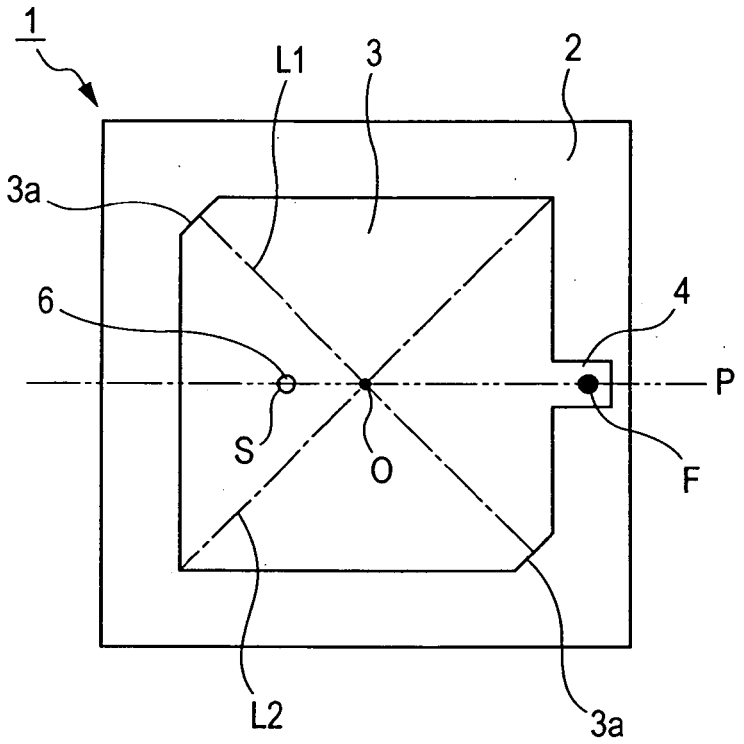


FIG. 2

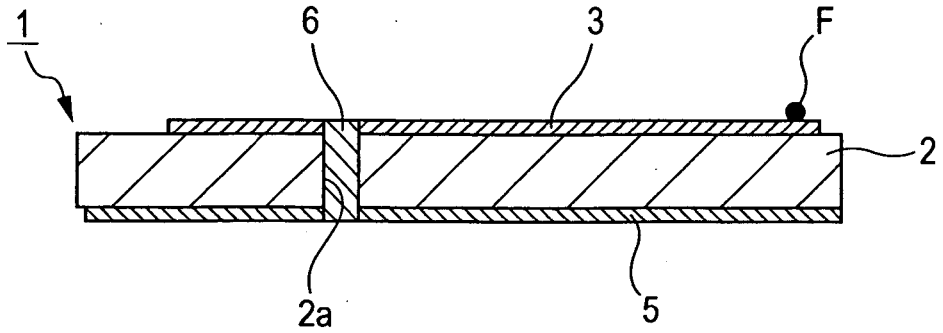


FIG. 3

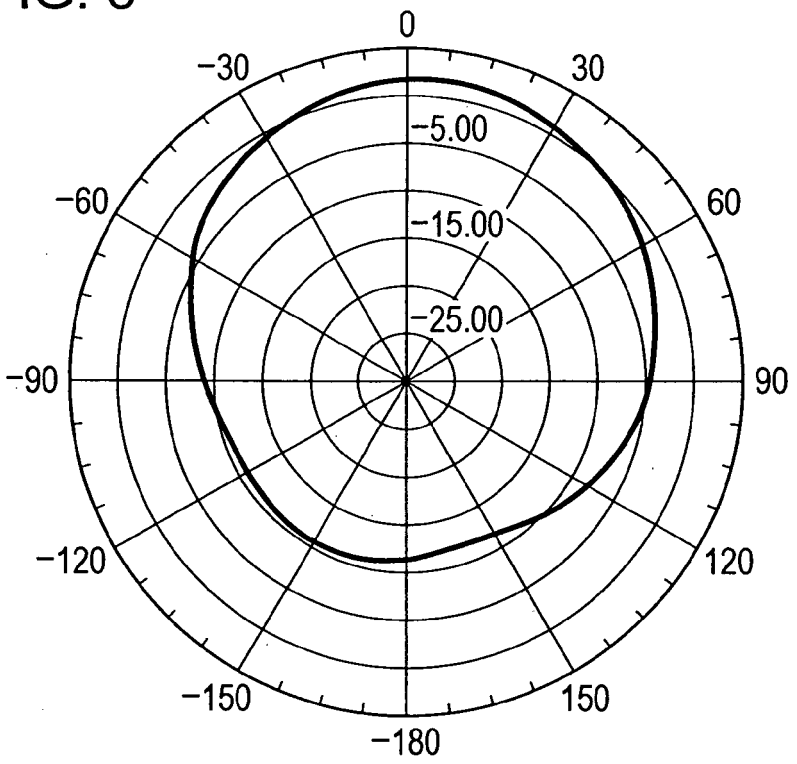
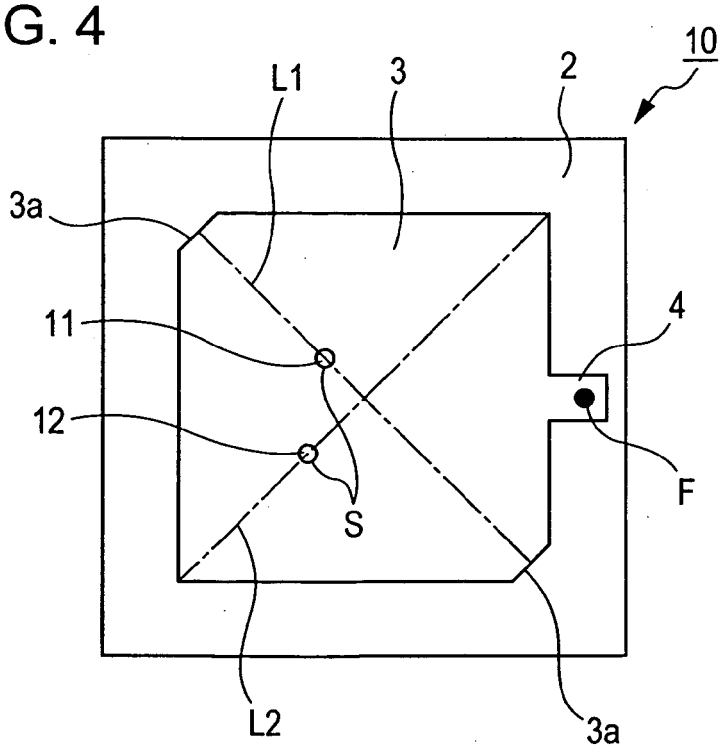

0
-30
30
-5.00
-60
-15.00
60
-25.00
-90
90
-120
120
-150
150
-180

FIG. 4


10
L1
3
2
3a
11
4
12
F
S
L2
3a

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 02 5245

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	EP 1 241 733 A (CIT ALCATEL [FR]) 18 September 2002 (2002-09-18)	1	INV. H01Q9/04
A	* paragraphs [0033] - [0037] * * figure 1 *	2-4	H01Q1/38

X	US 2004/196200 A1 (SIEVENPIPER DANIEL F [US]) 7 October 2004 (2004-10-07)	1	
A	* paragraphs [0030] - [0032] * * figure 3 *	2-4	

Y	WEN-SHYANG CHEN: "Inset-microstripline-fed circularly polarized microstrip antennas" ANTENNAS AND PROPAGATION SOCIETY, 1999. IEEE INTERNATIONAL SYMPOSIUM 1999 ORLANDO, FL, USA 11-16 JULY 1999, PISCATAWAY, NJ, USA,IEEE, US, vol. 1, 11 July 1999 (1999-07-11), pages 260-263, XP010348247 ISBN: 0-7803-5639-X * the whole document *	1,2,4	
	-----		TECHNICAL FIELDS SEARCHED (IPC)
Y	WO 01/31739 A (ANTENNAS AMERICA INC [US]) 3 May 2001 (2001-05-03)	1,2,4	H01Q
A	* page 3, line 5 - page 4, line 29 * * figure 1 *	3	

A	FR 2 552 937 A1 (DASSAULT ELECTRONIQUE [FR]) 5 April 1985 (1985-04-05) * page 4, line 23 - page 5, line 29 * * page 8, lines 19-24 * * figures 1,4 *	1-4	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	28 February 2007	Kruck, Peter

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

3

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 06 02 5245

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

28-02-2007

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1241733 A	18-09-2002	CN 1375890 A	23-10-2002
		FR 2822301 A1	20-09-2002
		JP 2002314326 A	25-10-2002
		US 2003011521 A1	16-01-2003
US 2004196200 A1	07-10-2004	NONE	
WO 0131739 A	03-05-2001	AU 3434201 A	08-05-2001
FR 2552937 A1	05-04-1985	DE 3436228 A1	11-04-1985
		GB 2150356 A	26-06-1985

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 5259731 A **[0003]**