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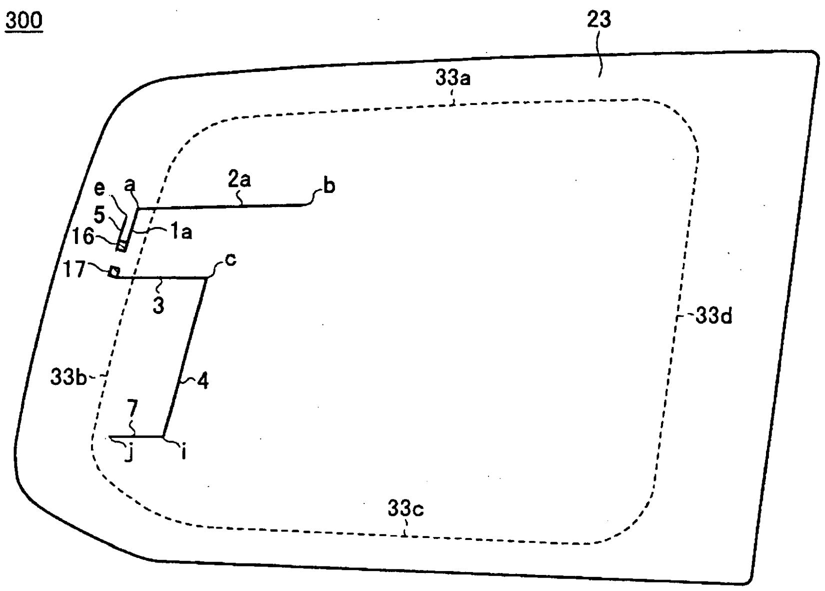
(54) **Glass antenna and vehicular window glass including the same**

(57) A glass antenna which is provided on or in a windrow glass 23 includes an upper feeding portion 16 and a lower feeding portion 17 which are aligned in a vertical direction, a first L-shaped element which is formed into an L-shape geometry by an element 1a which extends from the upper feeding portion 16 as a starting point and an element 2a which extends from the element 1a as a starting point, a second L-shaped element which is formed into an L-shaped geometry by an element 3 which extends rightwards from the lower feeding portion 17 as a starting point and an element 4 which extends downwards from the element 3 as a starting point, an element 5 which extends upwards from the upper feeding portion 16 as a starting point and an element 6 which extends downwards from the lower feeding portion 17 as a starting point.

FIG. 3



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Description

TECHNICAL FIELD

[0001] The present invention relates to a glass antenna which is provided on a glass plate. The present invention also relates to a vehicular windrow glass on which a glass antenna is provided.

RELATED ART

[0002] As related art, there are known glass antennas which can receive digital audio broadcasting (DAB) (for example, JP-A-H10-327009, JP-A-2000-307321, US-B-6924771, EP-A-1732160).

[0003] DAB includes two different frequency bands such as a band III of 174 to 240 MHz and an L band of 1452 to 1492 MHz.

[0004] However, in the case of a dual band in which a frequency band includes two frequency bands like the DAB, since the bands are not close to each other, it is difficult to design and fabricate a glass antenna having a sufficient reception performance which can deal with both the frequency bands.

SUMMARY

[0005] It is an object of the present invention to provide a glass antenna having reception characteristics which can deal with a dual band like the DAB and a vehicular windrow glass which includes the glass antenna.

[0006] A glass antenna to be provided on or in a glass plate, according to the invention, comprises: when looking at a surface of the glass plate while facing the same, an upper feeding portion and a lower feeding portion which are aligned in a vertical direction; and

an antenna conductor having a first antenna conductor, a second antenna conductor and a third antenna conductor,

wherein the first antenna conductor includes a first L-shaped element which is formed into an L-shape geometry by a first element which extends from the upper feeding portion as a starting point and a second element which extends from the first element as a starting point and in which one of the first element and the second element extends upwards while the other extends rightwards,

wherein the second antenna conductor includes a second L-shaped element which is formed into an L-shaped geometry by a third element which extends rightwards from the lower feeding portion as a starting point and a fourth element which extends downwards from the third element as a starting point, and

wherein the third antenna conductor includes a fifth element which extends upwards from the upper feeding portion as a starting point.

[0007] A vehicular window glass, according to the invention, comprises the above-mentioned glass antenna.

[0008] According to the invention, it is possible to obtain reception characteristics which can deal with a dual band like the DAB.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 is a plan view of a vehicular glass antenna 100.
Fig. 2 is a plan view of a vehicular glass antenna 200.
Fig. 3 is a plan view of a vehicular glass antenna 300.
Fig. 4 is a plan view of a vehicular glass antenna REF.
Fig. 5 is a graph showing actually measured data of antenna gains when a conductor length L4 is changed.
Fig. 6 is a graph showing actually measured data of antenna gains when a conductor length L13 is changed.
Fig. 7 is a graph showing actually measured data of antenna gains when a conductor length L1a is changed.
Fig. 8 is a graph showing actually measured data of antenna gains when a conductor length L2b is changed.
Fig. 9 is a graph showing actually data of antenna gains when a conductor length L7 is changed.
Fig. 10 is a graph showing actually data of antenna gains when a conductor length (L5 + E) is changed.
Fig. 11 is a graph showing actually measured data of antenna gains when a conductor length (L6 + E) is changed.

DETAILED DESCRIPTION

[0010] Hereinafter, referring to the drawings, a mode for carrying out the invention will be described. In the drawings illustrating the mode, where there is no specific description regarding directions, directions on the drawings are to be referred to. In addition, directions referred to as being parallel or at right angles permit such deviations therefrom that do not damage the advantage of the invention. Plan views of vehicular glass antennas are views of those which result when a viewer looks at a glass plate while facing the same. With a glass plate according to the invention applied to a vehicular window glass, the plan views each show a window glass as being seen from an inside of a passenger compartment of a vehicle in such a state that the window glass is fitted on the vehicle. However, the plan views may be referred to as those showing the window glass as being seen from an outside of the vehicle. For example, when the window glass is used as a side window which is mounted in a lateral side portion of the vehicle, a left-right direction on the drawings corresponds to a front-rear or longitudinal direction of the vehicle. The invention may be applied not only to the side window but also to a rear window which is mounted at the rear of the vehicle, a windshield which is mounted at the front of the vehicle, and glass plates other than vehicular glass plates (for example, window glass for buildings and window glass for marine vessels and so on).

[0011] Fig. 1 is a plan view of a vehicular glass antenna 100 which is a first embodiment of the invention. Fig. 2 is a plan view of a vehicular glass antenna 200 which is a second embodiment of the invention. The glass antennas 100, 200 are antennas which are provided on or in a window glass 23 which is a side window of a vehicle. Figs. 1, 2 show views as seen from an inside of the vehicle, and a left-hand side of each drawing corresponds to a rear side of the vehicle. A vertical direction in each drawing corresponds to a vertical direction of the vehicle, and a lower side of each drawing corresponds to road surface side.

[0012] The glass antennas 100, 200 are a dipole-type antenna provided on the window glass 23 in a planar fashion and include antenna conductors and an upper feeding portion 16 and a lower feeding portion 17 which are aligned in a vertical direction along a side edge of the window glass 23 with a space provided therebetween. The upper feeding portion 16 and the lower feeding portion 17 constitute a pair of feeding points for the antenna conductors. The glass antennas 100, 200 have at least a first antenna conductor, a second antenna conductor and a third antenna conductor as an antenna conductor pattern.

[0013] The first antenna conductor includes a first L-shaped element which is formed into an L-shaped geometry by a first element which extends from the upper feeding portion 16 as a starting point and a second element which extends from the first element as a starting point. For example, to form the L-shaped element, the second element extends in the direction which is at right angles or at substantially right angles to the direction in which the first element extends. In addition, one of the first element and the second element extends upwards and the other extends rightwards.

[0014] In Fig. 1, an element 1a which extends upwards in a straight line from the upper feeding portion 16 as a starting point is depicted as the first element, and an element 2a which extends rightwards in a straight line from a terminating end portion a of the upper extension of the element 1a as a starting point is depicted as the second element. The element 2a extends to a terminating end b of the extension of the first antenna conductor. On the other hand, in Fig. 2, an element 1b which extends rightwards in a straight line from the upper feeding portion 16 as a starting point is depicted as the first element, and an element 2b which extends upwards in a straight line from a terminating end g of the rightward extension of the element 1b as a starting point is depicted as the second element. The element 2b extends to a terminating end h of the extension of the first antenna conductor.

[0015] The second antenna conductor includes a second L-shaped element which is formed into an L-shaped geometry by a third element which extends rightwards from the lower feeding portion 17 as a starting point and a fourth element which extends downwards from the third element as a starting point. For example, to form the L-shaped element, the fourth element extends in the direction which is at right angles or at substantially right angles to the direction in which the third element extends.

[0016] In Figs. 1, 2, an element 3 which extends rightwards in a straight line from the lower feeding portion 17 as a starting point is depicted as the third element, and an element 4 which extends downwards in a straight line from a terminating end portion c of the rightward extension of the third element 3 as a staring point is depicted as the fourth element. The element 4 extends to a terminating end d of the extension of the second antenna conductor.

[0017] The third antenna conductor includes a fifth element which extends upwards from the upper feeding portion 16 as a starting point. In Figs. 1, 2, an element 5 which extends upwards in a straight line from the upper feeding portion 16 as a starting point is depicted as a fifth element. The fifth element 5 extends to a terminating end e of the third antenna conductor. In particular, in the case of Fig. 1, the element 5 extends along a left-hand side edge of the window glass 23 on a left-hand side area of the element 1a with a space provided therebetween.

[0018] The glass antennas 100, 200 may have, as an antenna conductor pattern, a fourth antenna conductor which includes a sixth element which extends downwards from the lower feeding portion 17 as a starting point. In Figs. 1, 2, an element 6 which extends downwards in a straight line from the lower feeding portion 17 as a starting point is depicted as the sixth element. The sixth element extends to a terminating end f of the fourth antenna conductor.

[0019] In this way, according to the glass antennas formed as depicted in Figs. 1, 2, the upper feeding portion 16 is electrically connected to a signal line of an external signal processing system (for example, an on-board amplifier) via a predetermined first conductive member, while the lower feeding portion 17 is electrically connected to an external grounding line (for example, a grounding of the signal processing system) via a predetermined second conductive member, whereby reception characteristics can be obtained which can deal with a dual band such as the DAB. In particular, by one or two or more of the elements which extend upwards or downwards such as the element 1a, the element 2b, the element 4, the element 5 and the element 6 being provided on or in the window glass 23 so as to be vertical to the earth's surface (in particular, a horizontal plane), a radio wave such as a vertically-polarized wave of a dual band such as the DAB can be received with a better sensitivity. A mounting angle of the window glass 23 on the vehicle is preferably in the range from 30 to 90° and more preferably in the range of 60 to 90° with respect to the earth's surface.

[0020] As the first and second conductive members, for example, feeding wires such as an AV wire and a coaxial cable are used. When a coaxial cable is used, an internal conductor of the coaxial cable may be electrically connected the upper feeding portion 16, while an external conductor of the coaxial cable may be electrically connected to the lower feeding portion 17. In addition, a configuration may be adopted in which a connector for electrically connecting a conductive member connected to the signal processing system to each of the upper feeding portion 16 and the lower feeding portion 17 is mounted in each of the upper feeding portion 16 and the lower feeding portion 17. The attachment of the internal conductor and external conductor of the coaxial cable to the upper feeding portion 16 and the lower feeding portion 17, respectively, is facilitated by the connectors. Further, a configuration may also be adopted in which a projecting conductive member is placed on each of the upper feeding portion 16 and the lower feeding portion 17 so that the projecting conductive members are brought into contact with or are fitted in a flange of a vehicle body on which the window glass 23 is mounted.

[0021] According to the glass antennas formed as depicted in Figs. 1, 2, even in the event that a tuning is implemented with respect to the length of the first antenna conductor and/or the second antenna conductor so as to receive the low-frequency radio wave of the dual band while satisfying a predetermined requirement standard, the reception characteristics of the high-frequency radio wave of the dual band can be kept least affected by the tuning. Similarly, even in the event that a tuning is implemented with respect to the length of the third antenna conductor and/or the fourth antenna conductor so as to receive the high-frequency radio wave of the dual band, the reception characteristics of the low-frequency radio wave of the dual band can be kept least affected by the tuning. Namely, the tunings are facilitated.

[0022] As is shown in Fig. 3, the second antenna conductor may include a seventh element which extends leftwards from the fourth element as a starting point. In Fig. 3, an element 7 which extends leftwards in a straight line from a terminating end portion i of the downward extension of the element 4 as a starting point is depicted as the seventh element. The element 7 extends to a terminating end j of the second antenna conductor.

[0023] The "terminating end portion" may be a terminating point of the elements or lie in proximity to the terminating point or in a conductor portion just before the terminating point. The connecting portion where the elements are connected may have a curvature.

[0024] The antenna conductors, the upper feeding portion 16 and the lower feeding portion 17 are formed by printing and firing a paste containing a conductive metal such as a silver paste on a vehicle-interior side surface of the window glass, for example. However, the forming method is not limited thereto. For example, a linear or foil-like material made of a conductive substance such as copper may be formed on an internal side surface or an external side surface of a window glass or may be affixed to the window glass with an adhesive. Alternatively, such a linear or foil-like material may be provided in an interior of the window glass itself.

[0025] Shapes of the upper feeding portion 16 and the lower feeding portion 17 and a space between the upper feeding portion 16 and the lower feeding portion 17 may be determined in accordance with the shapes of the mounting surfaces of the conductive members and the space between the mounting surfaces, respectively. For example, in consideration of mounting, a quadrangular shape such as a square, substantially square, rectangular or substantially rectangular shape or a polygonal shape is preferred. Alternatively, a circular shape such as a circle, substantially circle, oval or substantially oval shape may be adopted. An area of the upper feeding portion 16 and an area of the lower feeding portion 17 may be the same or different from each other.

[0026] A glass antenna may be adopted which is produced by providing a conductor layer including antenna conductors in an interior or on a surface of a synthetic resin film and applying the synthetic resin film with the conductor layer on an internal side surface or an external side surface of a window glass plate. Further, a glass antenna may be adopted which is produced by forming a flexible circuit board on which antenna conductors are formed on an internal side surface or an external side surface of the window glass.

[0027] A concealing film is formed on a surface of the window glass 23, and the feeding portions and part or the whole of the antenna conductors may be provided on the concealing film. Ceramics such as a black ceramic film are raised as the concealing film. By this means, when the window glass is seen from an outside of the vehicle, the part of the antenna conductors provided on the concealing film is made invisible from the outside of the vehicle by the concealing film, whereby the window glass is superior in design. In the drawings, by the feeding portions and part of the antenna conductors being formed on the concealing film (between edges 33a to 33d of the concealing film and edges of the window glass 23), only fine straight line portions of the conductors become visible in view from vehicle-interior side, which is preferable from the viewpoint of design.

[0028] In this invention, as broadcast frequency bands to be received, there are a predetermined first broadcast frequency band and a predetermined second broadcast frequency band which is higher than the first broadcast frequency band. When a wavelength in the air at a central frequency of the first broadcast frequency band is referred to as λ_{01}, a glass shortening coefficient of wavelength is referred to as k_1 (where k_1 = 0.54) and $\lambda_{g1} = \lambda_{01} \cdot k_1$, in the case of the glass antenna 100 shown in Fig. 1, in the event that a conductor length L1a of the element 1a which corresponds to the first element which is a vertical component of the first antenna conductor is preferably (1/24) λ_{g1} or longer, or more preferably (1/12) λ_{g1} or longer, within a range where the element 1a stays within the window glass 23, a preferred result can be obtained in increasing the antenna gain in the first broadcast frequency band.

[0029] Here, when the band III (174 to 240 MHz) is set as the first broadcast frequency band, a center frequency thereof is 207 MHz. Consequently, when the antenna gain of the band III is attempted to be increased, in case the speed of a radio wave is referred to as 3.0×10^8m/s, it is good to adjust the conductor length L1a of the element 1a is adjusted preferably to be 35 mm or longer, or more preferably to be 66 mm or longer.

[0030] In the case of the glass antenna 200 shown in Fig. 2, in the event that a conductor length L2b of the element 2b which corresponds to the second element which is a vertical component of the first antenna conductor is preferably (1/12) λ_{g1} or longer, more preferably (1/8) λ_{g1} or longer, or further preferably (1/6) λ_{g1} or longer, within a range where the element 2b stays within the window glass 23, a preferred result can be obtained in increasing the antenna gain in the first broadcast frequency band. Consequently, when the antenna gain of the band III is attempted to be increased, it is good to adjust the conductor length L2b of the element 2b is adjusted preferably to be 66 mm or longer, more preferably to be 97 mm or longer, or further preferably to be 130 mm or longer.

[0031] In the event that an overall length of the first antenna conductor, that is, a sum of the conductor lengths of the element 1a and the element 2a or the conductor lengths of the element 1b and the element 2b is preferably 0.15 λ_{g1} or longer and 0.3 λ_{g1} or shorter, or more preferably 0.2 λ_{g1} or longer and 0.27 λ_{g1} or shorter, a preferred result can be obtained in increasing the antenna gain in the first broadcast frequency band. Consequently, when the antenna gain of the band III is attempted to be increased, it is good to adjust the overall length of the first antenna conductor is adjusted preferably to be 120 mm or longer and 240 mm or shorter, or more preferably to be 160 mm or longer and 210 mm or shorter.

[0032] In the event that a conductor length L4 of the element 4 which corresponds to the fourth element which is a vertical component of the second antenna conductor is preferably (1/5) λ_{g1} or longer, or more preferably (1/4) λ_{g1} or longer, within a range where the element 4 stays within the window glass 23, a preferred result can be obtained in increasing the antenna gain in the first broadcast frequency band. Consequently, when the antenna gain of the band III is attempted to be increased, it is good to adjust the conductor length L4 of the element 4 is adjusted preferably to be 150 mm or longer, or more preferably to be 200 mm or longer.

[0033] In the event that an overall length of the second antenna conductor, that is, a sum of the conductor lengths of the element 3 and the element 4 is preferably 0.3 λ_{g1} or longer and 0.64 λ_{g1} or shorter, or more preferably 0.35 λ_{g1} or longer and or 0.52 λ_{g1} or shorter, a preferred result can be obtained in increasing the antenna gain in the first broadcast frequency band within the range where the element 3 and the element 4 stay within the window glass 23. Consequently, when the antenna gain of the band III is attempted to be increased, it is good to adjust the overall length of the second antenna conductor is adjusted preferably to be 240 mm or longer and 500 mm or shorter, or more preferably to be 280 mm or longer and 400 mm or shorter.

[0034] In this invention, when a wavelength in the air at a central frequency of the second broadcast frequency band which is higher than the first broadcast frequency band is referred to as λ_{02}, a glass shortening coefficient of wavelength is referred to as k_2(where $k_2 = 0.74$) and $\lambda_{g2} = \lambda_{02} \cdot k_2$, in the event that a length (L5 + E) of a conductor line which connects shortest between the terminating end e of the extension of the element 5 and an end of the upper feeding portion 16 is preferably 0.17 λ_{g2} or longer and 0.27 λ_{g2} or shorter, or more preferably 0.19 λ_{g2} or longer and 0.26 λ_{g2} or shorter, a preferred result can be obtained in increasing the antenna gain in the second broadcast frequency band. In the case of Figs. 1 to 3, the end of the upper feeding portion 16 corresponds to a lower end of the upper feeding portion 16 which is the end facing the lower feeding portion 17. In addition, "E" of (L5 + E) corresponds to a length of a side of the square upper feeding portion 16.

[0035] Here, when the L band (1452 to 1492 MHz) is set as the second broadcast frequency band, a center frequency thereof is 1472 MHz. Consequently, when the antenna gain of the L band is attempted to be increased, in case the speed of a radio wave is referred to as 3.0×10^8m/s, it is good to adjust the length (L5 + E) of the conductor line is adjusted preferably to be 26 mm or longer and 40 mm or shorter, or more preferably to be 30 mm or longer and 38 mm or shorter.

[0036] In the event that a length (L6 + E) of a conductor line which connects shortest between the terminating end f of the extension of the element 6 and an end of the lower feeding portion 17 is preferably 0.07 λ_{g2} or longer and 0.2 λ_{g2} or shorter, or more preferably 0.13 λ_{g2} or longer and 0.19 λ_{g2} or shorter, a preferred result can be obtained in increasing the antenna gain in the second broadcast frequency band. In the case of Figs. 1 to 3, the end of the lower feeding portion 17 corresponds to an upper end of the lower feeding portion 17 which is the end facing the upper feeding portion 16. In addition, "E" of (L6 + E) corresponds to a length of a side of the square lower feeding portion 17. Consequently, when the antenna gain of the L band is attempted to be increased, it is good to adjust the length (L6 + E) of the conductor line is adjusted preferably to be 12 mm or longer and 30 mm or shorter, or more preferably to be 20 mm or longer and 28 mm or shorter.

[Examples]

[0037] Examples are described in which the glass antennas according to the invention are applied to a vehicular window glass. Actually measured results of antenna gains of automotive glass antennas which are fabricated by mounting the glass antennas formed as shown in Figs. 1 to 4 on a side window of an actual vehicle are described.

[0038] Antenna gains are actually measured in such a state that the automotive window glass plates formed with the glass antenna are assembled into a window frame of an automobile on a turntable while being inclined at about 75° relative to the horizontal plane. Connectors are attached to the feeding portions and are connected to a network analyzer via feeder wires. The turntable rotates so that radio waves are applied onto the window glass in every direction from the horizontal direction.

[0039] The measurement of antenna gains is performed by setting a vehicle center of the automobile, assembled with the glass plate on which the glass antenna is formed, at the center of the turntable and rotating the automobile through 360°. Antenna gains are measured every 3 MHz within the frequency range of the band III and every 1.7 MHz within the frequency range of the L band at every time the turntable rotates through 3°. Antenna gains are measured with an elevation angle between a transmitting position of radio waves and the antenna conductors being in a substantially horizontal direction (when a plane parallel to the ground is referred to as elevation angle = 0° and a zenith direction is referred to as elevation angle = 90°, in the direction where the elevation angle = 0°). Antenna gains are standardized based on a half-wavelength dipole antenna so that the gain of the half-wavelength dipole antenna is 0dB.

[Example 1]

[0040] Fig. 4 is a plan view of a vehicular glass antenna REF which is compared with the vehicular glass antenna 100 (refer to Fig. 1) which is the embodiment of the invention. Like the vehicular glass antenna which is the embodiment of the invention, the vehicular glass antenna REF is also a dipole-type glass antenna.

[0041] A form of a second antenna conductor of the glass antenna REF differs from that of the glass antenna 100. Namely, the second antenna conductor of the glass antenna REF includes an L-shaped element which is formed into an L-shaped geometry by an element 13 which extends downwards from a lower feeding portion 17 as a starting point and an element 14 which extends rightwards from the element 13 as a starting point.

[0042] Fig. 5 is a graph showing actually measured data of antenna gains of an automotive high-frequency glass antenna fabricated by mounting the glass antenna 100 formed as is shown in Fig. 1 on a side window of an actual vehicle when a conductor length L4 of the element 4 is changed while a sum of a conductor length L3 of the element 3 and the conductor length L4 keeps constant at 300 mm. Fig. 6 is a graph showing actually measured data of antenna gains of an automotive high-frequency glass antenna fabricated by mounting the glass antenna REF formed as is shown in Fig. 4 on a side window of an actual vehicle when a conductor length L 13 is changed while a sum of the conductor length L13 of the element 13 and a conductor length L14 of the element 14 keeps constant at 300 mm. Vertical axes of Figs. 5, 6 represent mean values of antenna gains measured every 3 MHz in the band III (170 to 240 MHz).

[0043] When the antenna gains shown in Figs. 5, 6 are actually measured, dimensions of the respective portions of the glass antennas are as follows. The unit is mm.

L1a: 37

L2a: 160

L5: 24

L6: 14,

where "L*" (* represents a reference numeral) denotes a conductor length of the element *. A conductor width of each element is 0.8 mm. The upper feeding portion 16 and the lower feeding portion 17 are both square with 10 mm sides. A space between the upper feeding portion 16 and the lower feeding portion 17 is 20 mm.

[0044] As is shown in Figs. 5, 6, the antenna gain in the band III is increased by means of the glass antenna 100 having the element 3 which extends rightwards from the lower feeding portion 17 as the starting point, compared with the glass antenna REF having the element which extends downwards from the lower feeding portion 17 as the starting point. As is shown in Fig. 5, as the conductor length L4 of the element 4 which is the vertical component of the second antenna conductor is lengthened, the antenna gain in the band III can be increased. For example, in the event that the conductor length L4 of the element 4 is 150 mm or longer, the antenna gain in the band III can be increased.

[Example 2]

[0045] Fig. 7 is a graph showing actually measured data of antenna gains of an automotive high-frequency glass antenna fabricated by mounting the glass antenna 100 formed as is shown in Fig. 1 on a side window of an actual vehicle when a conductor length L1a of the element 1a is changed while a sum of the conductor length L1a and a conductor length L2a of the element 2 keeps constant at 197 mm. Fig. 8 is a graph showing actually measured data of antenna gains of an automotive high-frequency glass antenna fabricated by mounting the glass antenna 200 formed as is shown in Fig. 2 on a side window of an actual vehicle when a conductor length L2b of the element 2b is changed while a sum of a conductor length L1b of the element 1b and the conductor length L2b keeps constant at 197 mm. Vertical axes of Figs. 7, 8 represent mean values of antenna gains measured every 3 MHz in the band III (170 to 240 MHz).

[0046] When the antenna gains shown in Figs. 7, 8 are actually measured, dimensions of the respective portions of the glass antennas are as follows. The unit is mm.

L3: 80

L4: 220

L5: 24

L6: 14.

Other dimensions are similar to those of Example 1.

[0047] As is shown in Figs. 7, 8, the antenna gain in the band III can be increased as the conductor length of the element 1a or 2b which extends in the vertical direction of the first antenna conductor is lengthened. For example, as is shown in Fig. 7, in the case of the glass antenna 100 formed as is shown in Fig. 1, in the event that the conductor length L1a of the element 1a which is the vertical component of the first antenna conductor is 35 mm or longer, the antenna gain in the band III can be increased. Also, as is shown in Fig. 8, in the case of the glass antenna 200 formed as is shown in Fig. 2, in the event that the conductor length L2b of the element 2b which is the vertical component of the first antenna conductor is 66 mm or longer, or further 97 mm or longer, the antenna gain in the band III can be increased.

[Example 3]

[0048] Fig. 9 is a graph showing actually measured data of antenna gains of an automotive high-frequency glass antenna fabricated by mounting a glass antenna 300 formed as is shown in Fig. 3 on a side window of an actual vehicle when a conductor length L7 of an element 7 is changed while a sum of a conductor length L4 of an element 4 and the conductor length L7 keeps constant at 220 mm. A vertical axis of Fig. 9 represents mean values of antenna gains measured every 3 MHz in the band III (170 to 240 MHz).

[0049] When the antenna gains shown in Fig. 9 are actually measured, dimensions of the respective portions of the glass antenna are as follows. The unit is mm.

L1a: 37
L2a 160
L3: 80.
Other dimensions are similar to those of Example 1.

[0050] As is shown in Fig. 9, as the conductor length L4 of the element 4 which extends in a vertical direction of a second conductor is lengthened (that is, as the conductor length L7 of the element 7 which extends in a horizontal direction of the second antenna conductor is shortened), the antenna gain in the band III can be increased.

[Example 4]

[0051] Fig. 10 is a graph showing actually measured data of antenna gains of an automotive high-frequency glass antenna fabricated by mounting only the element 5 and the feeding portions 16, 17 of the glass antenna 100 formed as is shown in Fig. 1 on a side window of an actual vehicle when a sum (L5 + E) of a conductor length L5 of the element 5 and a length E of the side of the upper feeding portion 16 is changed by changing the conductor length L5. A vertical axis of Fig. 10 represents mean values of antenna gains measured every 1.7 MHz in the L band (1452 to 1492 MHz).

[0052] A conductor width of the element 5 when antenna gains in Fig. 10 are actually measured is 0.8 mm. The upper feeding portion 16 and the lower feeding portion 17 are both square with 10 mm sides. A space between the upper feeding portion 16 and the lower feeding portion 17 is 20 mm.

[0053] As is shown in Fig. 10, in the event that the conductor length (L5 + E) is 26 mm or longer and 40 mm or shorter, the antenna gain in the L band can be increased.

[Example 5]

[0054] Fig. 11 is a graph showing actually measured data of antenna gains of an automotive high-frequency glass antenna fabricated by mounting only the elements 5, 6 and the feeding portions 16, 17 of the glass antenna 100 formed as is shown in Fig. 1 on a side window of an actual vehicle when a sum (L6 + E) of a conductor length L6 of the element 6 and a length E of the side of the lower feeding portion 17 is changed by changing the conductor length L6. A vertical axis of Fig. 11 represents mean values of antenna gains measured every 1.7 MHz in the L band (1452 to 1492 MHz).

[0055] Conductor widths of the elements 5, 6 when antenna gains in Fig. 11 are actually measured are 0.8 mm. The upper feeding portion 16 and the lower feeding portion 17 are both square with 10 mm sides. A space between the upper feeding portion 16 and the lower feeding portion 17 is 20 mm.

[0056] As is shown in Fig. 11, in the event that the conductor length (L6 + E) is 12 mm or longer and 30 mm or shorter, the antenna gain in the L band can be increased.

[Example 6]

[0057] A mean value of the antenna gains which are actually measured every 3 MHz in the whole band of the band III and a mean value of the antenna gains which are actually measured every 1.7 MHz in the whole band of the L band on the automotive high-frequency glass antenna fabricated by mounting the glass antenna 100 formed as is shown in Fig. 1 on the side window of the actual vehicle were calculated.

[0058] When the antenna gains of Example 6 are actually measured, dimensions of the respective portions of the glass antenna 100 are as follows. The unit is mm.

L1a: 37

L2a 160
L3: 80
L4: 220
L5: 24
L6: 14.
Other dimensions are similar to those of Example 1.

[0059] As a result, the mean value of the antenna gains in the whole band of the band III is -3.3dBd, and the mean value of the antenna gains in the whole band of the L band is -6.6dBd.

Claims

1. A glass antenna to be provided on or in a glass plate, comprising:

   when looking at a surface of the glass plate while facing the same,
   an upper feeding portion and a lower feeding portion which are aligned in a vertical direction; and
   an antenna conductor having a first antenna conductor, a second antenna conductor and a third antenna conductor,
   wherein the first antenna conductor includes a first L-shaped element which is formed into an L-shape geometry by a first element which extends from the upper feeding portion as a starting point and a second element which extends from the first element as a starting point and in which one of the first element and the second element extends upwards while the other extends rightwards,
   wherein the second antenna conductor includes a second L-shaped element which is formed into an L-shaped geometry by a third element which extends rightwards from the lower feeding portion as a starting point and a fourth element which extends downwards from the third element as a starting point, and
   wherein the third antenna conductor includes a fifth element which extends upwards from the upper feeding portion as a starting point.

2. A glass antenna as set forth in Claim 1, wherein
   the first element extends upwards from the upper feeding portion as a starting point.

3. A glass antenna as set forth in Claim 2, wherein
   there are a predetermined first broadcast frequency band and a predetermined second frequency band which is higher than the first broadcast frequency band, a wavelength in the air at a central frequency of the first broadcast frequency band is referred to as λ_{01}, and a glass shortening coefficient of wavelength is referred to as k_1 (where $k_1 = 0.54$) and $\lambda_{g1} = \lambda_{01} \cdot k_1$, and wherein
   a conductor length of the first element is (1/24) λ_{g1} or longer.

4. A glass antenna as set forth in Claim 2, wherein
   a conductor length of the first element is 35 mm or longer.

5. A glass antenna as set forth in any of Claims 1 to 4, wherein
   there are a predetermined first broadcast frequency band and a predetermined second frequency band which is higher than the first broadcast frequency band, a wavelength in the air at a central frequency of the first broadcast frequency band is referred to as λ_{01}, and a glass shortening coefficient of wavelength is referred to as k_1 (where $k_1 = 0.54$) and $\lambda_{g1} = \lambda_{01} \cdot k_1$, and wherein
   a conductor length of the fourth element is (1/5) λ_{g1} or longer.

6. A glass antenna as set forth in any of Claims 1 to 4, wherein
   the conductor length of the fourth element is 150 mm or longer.

7. A glass antenna as set forth in any of Claims 1 to 6, wherein
   there are a predetermined first broadcast frequency band and a predetermined second broadcast band which is higher than the first broadcast band, a wavelength in the air at a central frequency of the second broadcast frequency band is referred to as λ_{02}, a glass shortening coefficient of wavelength is referred to as k_2 (where $k_2 = 0.74$) and $\lambda_{g2} = X_{02} \cdot k_2$, and wherein
   a length of a conductor line which connects shortest between a terminating end of an extension of the fifth element and an end of the upper feeding portion is 0.17 λ_{g2} or longer and 0.27 λ_{g2} or shorter.

8. A glass antenna as set forth in any of Claims 1 to 6, wherein
   a length of a conductor line which connects shortest between a terminating end of an extension of the fifth element and an end of the upper feeding portion is 26mm or longer and 40 mm or shorter.

9. A glass antenna as set forth in any of Claims 1 to 8, wherein
   the antenna conductor has further a fourth antenna conductor, and wherein
   the fourth antenna conductor includes a sixth element which extends downwards from the lower feeding portion as a starting point.

10. A glass antenna as set forth in Claim 9, wherein
   there are a predetermined first broadcast frequency

band and a predetermined second broadcast band which is higher than the first broadcast band, a wavelength in the air at a central frequency of the second broadcast frequency band is referred to as λ_{02}, a glass shortening coefficient of wavelength is referred to as k_2 (where $k_2 = 0.74$) and $\lambda_{g2} = \lambda_{02} \cdot k_2$, and wherein
a length of a conductor line which connects shortest between a terminating end of an extension of the sixth element and an end of the lower feeding portion is 0.07 λ_{g2} or longer and 0.2 λ_{g2} or shorter.

11. A glass antenna as set forth in Claim 9, wherein
a length of a conductor line which connects shortest between a terminating end of an extension of the sixth element and an end of the lower feeding portion is 12mm or longer and 30 mm or shorter.

12. A glass antenna as set forth in any of Claims 1 to 11, wherein
the second antenna conductor includes a seventh element which extends leftwards from the fourth element as a starting point.

13. A glass antenna as set forth in any of Claims 1 to 12, wherein
a first broadcast frequency band to be received is present in a range from 174 to 240 MHz, and a second broadcast frequency band to be received which is higher than the first broadcast frequency band is present in a range from 1452 to 1492 MHz.

14. A vehicular window glass comprising a glass antenna as set forth in any of Claims 1 to 13.

FIG. 1

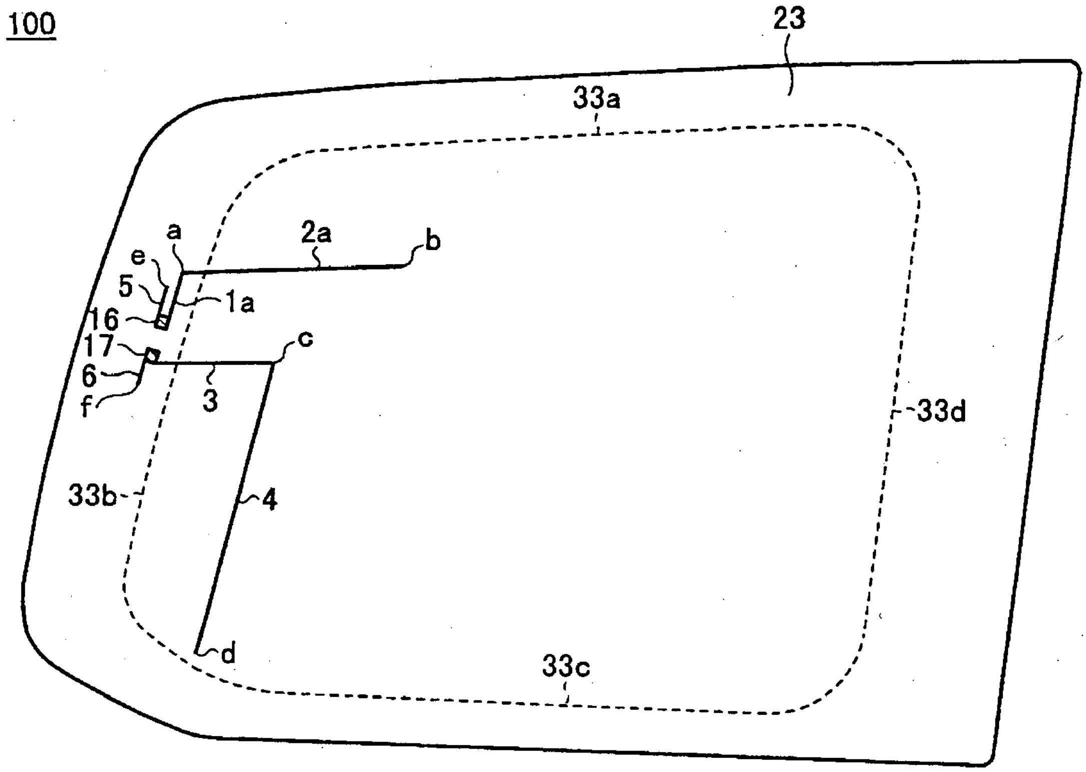

FIG. 2

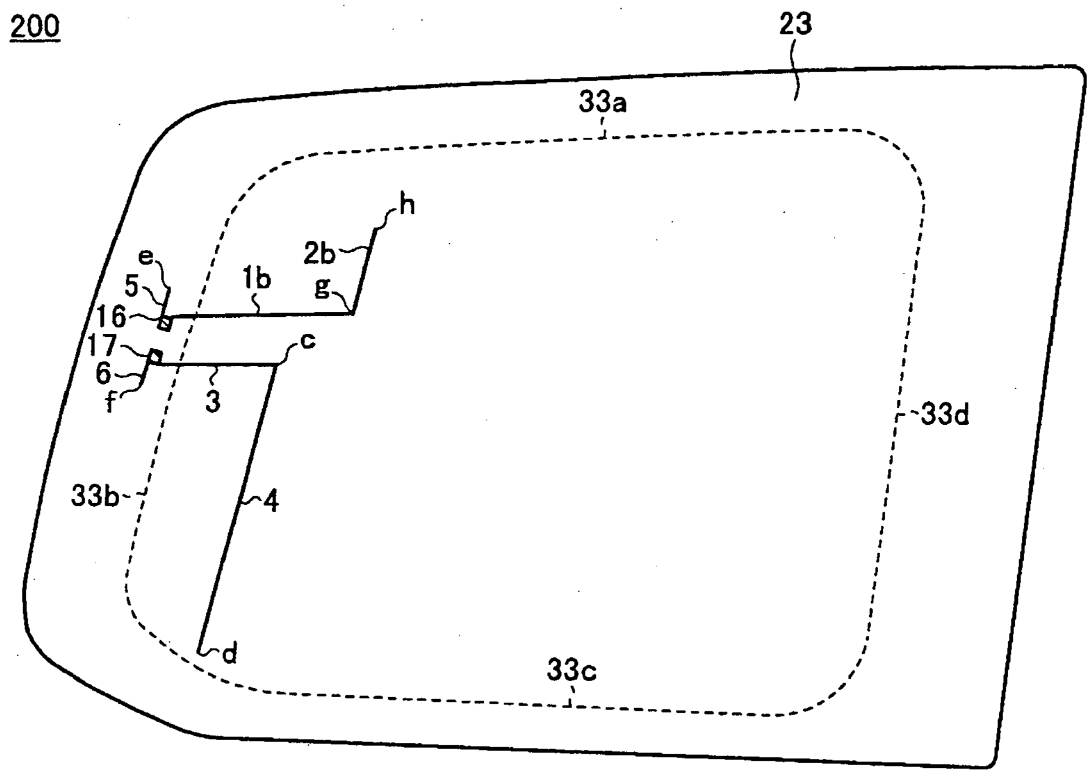

FIG. 3

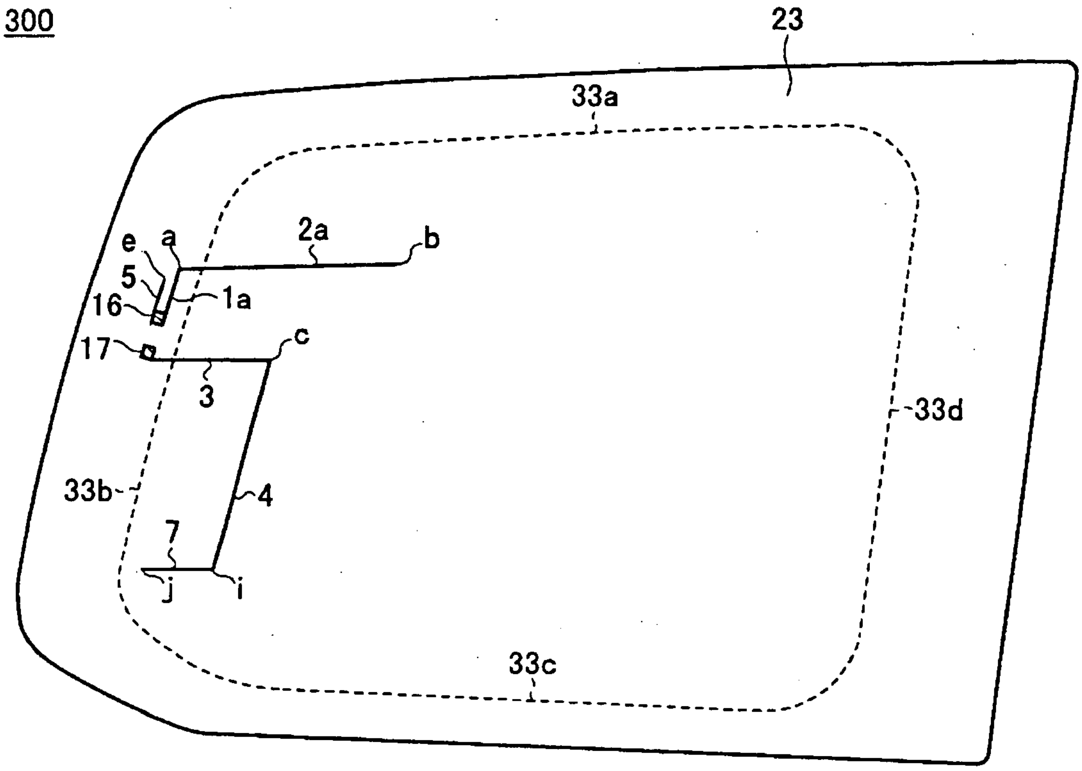

FIG. 4

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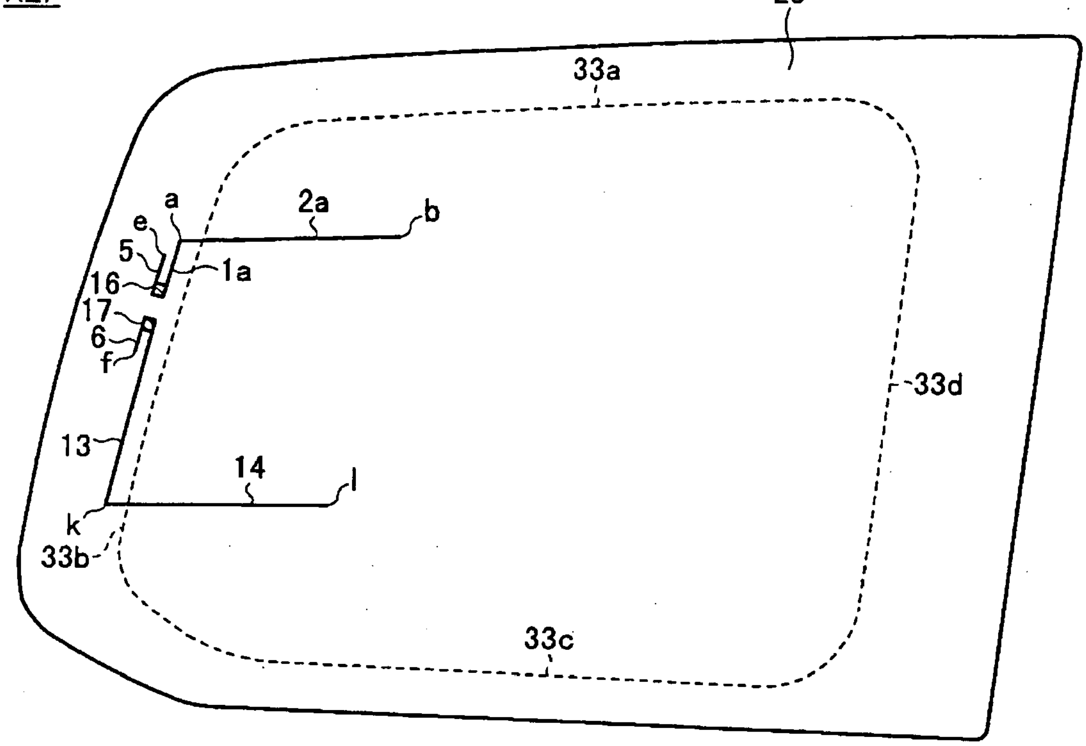


FIG. 5

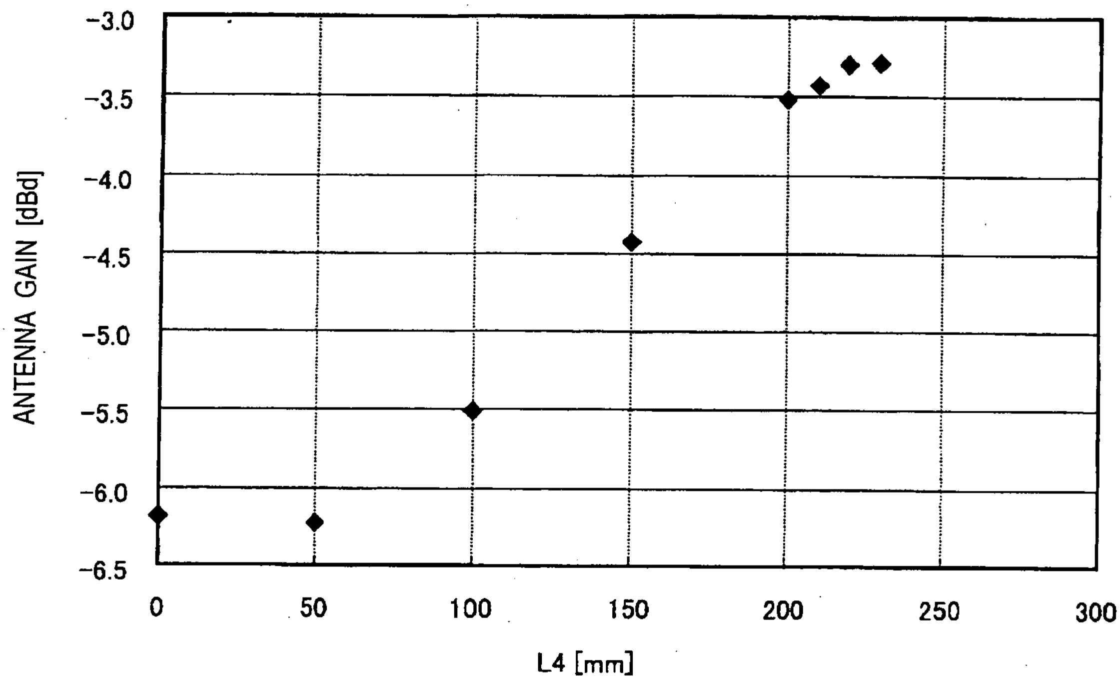

-3.0
-3.5
-4.0
-4.5
-5.0
-5.5
-6.0
-6.5
ANTENNA GAIN [dBd]
0
50
100
150
200
250
300
L4 [mm]

FIG. 6

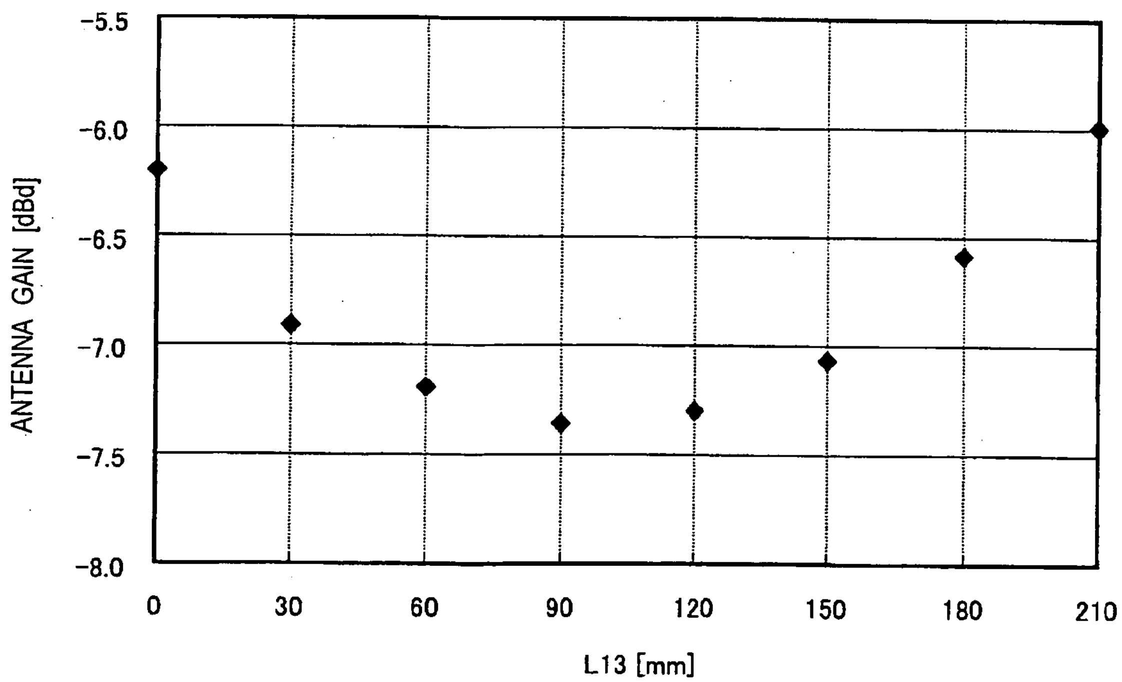

-5.5
-6.0
-6.5
-7.0
-7.5
-8.0
ANTENNA GAIN [dBd]
0
30
60
90
120
150
180
210
L13 [mm]

FIG. 7

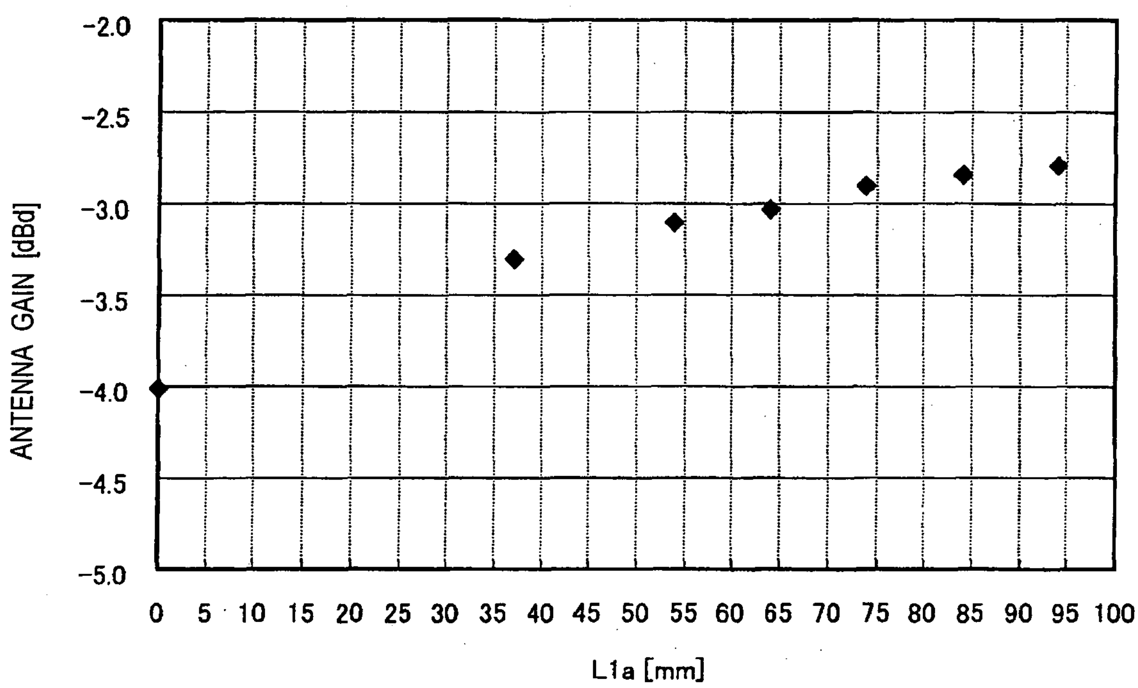
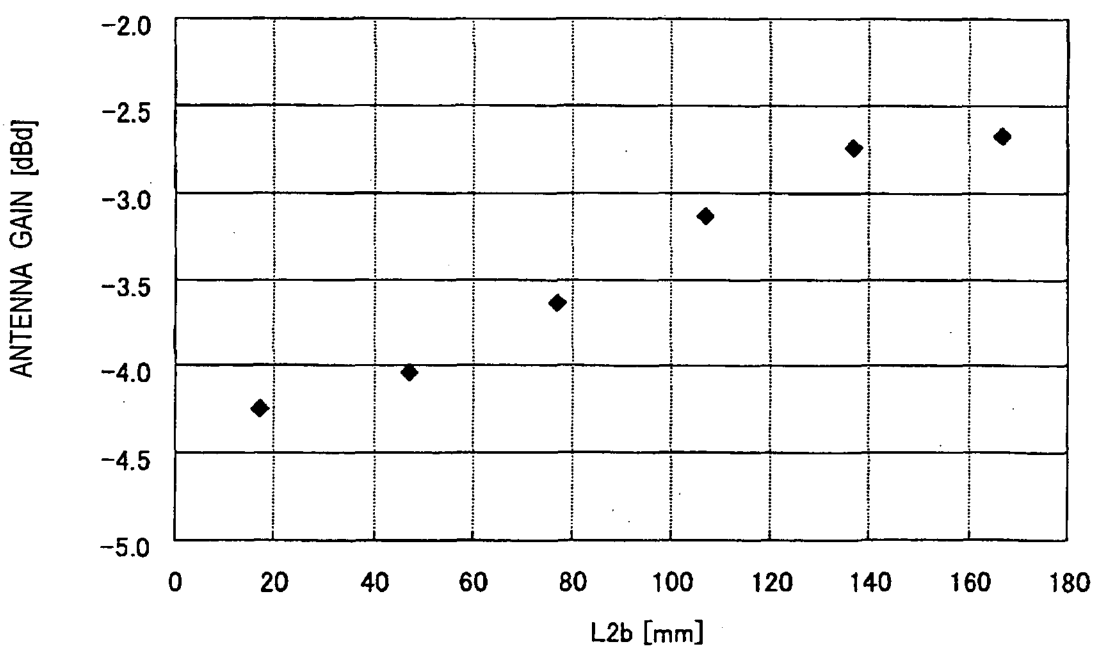

-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
-5.0
ANTENNA GAIN [dBd]
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
L1a [mm]

FIG. 8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-2.5
-3.0
-3.5
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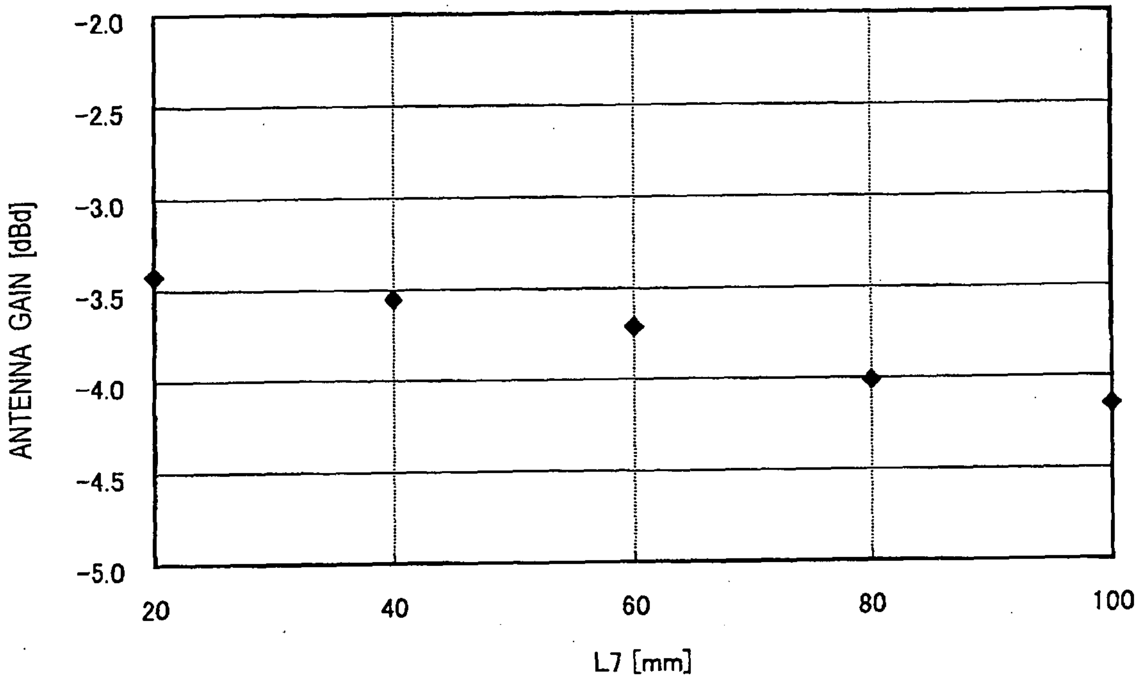
-4.5
-5.0
ANTENNA GAIN [dBd]
0 20 40 60 80 100 120 140 160 180
L2b [mm]

FIG. 9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-3.0
-3.5
-4.0
-4.5
-5.0
ANTENNA GAIN [dBd]
20
40
60
80
100
L7 [mm]

FIG. 10

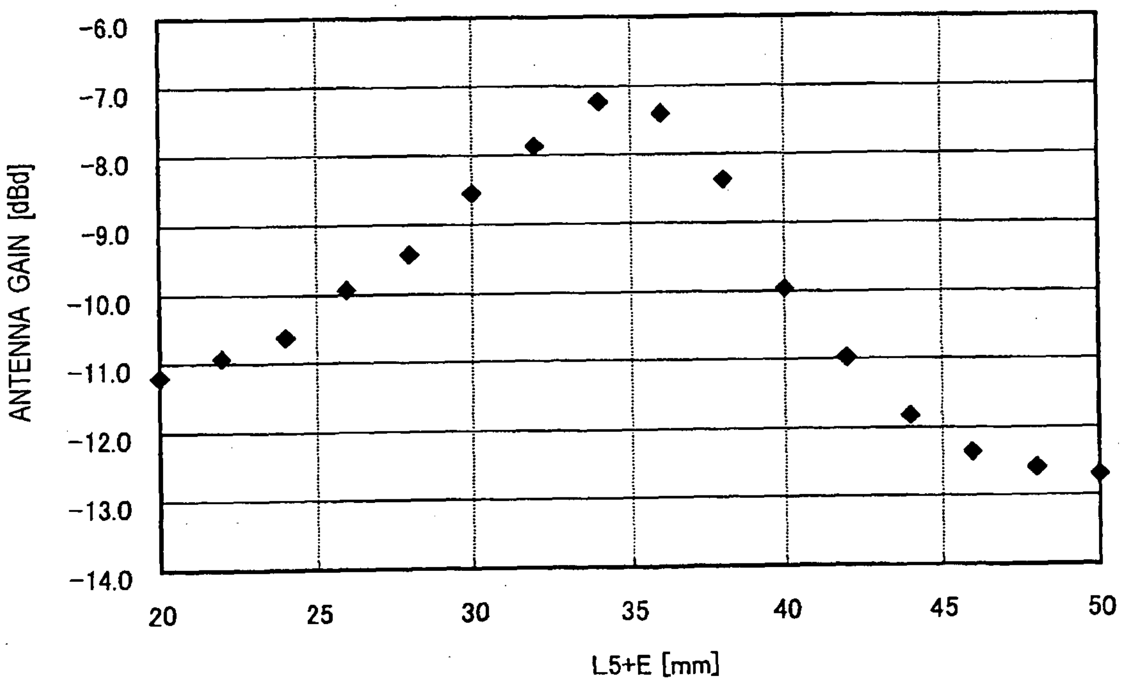
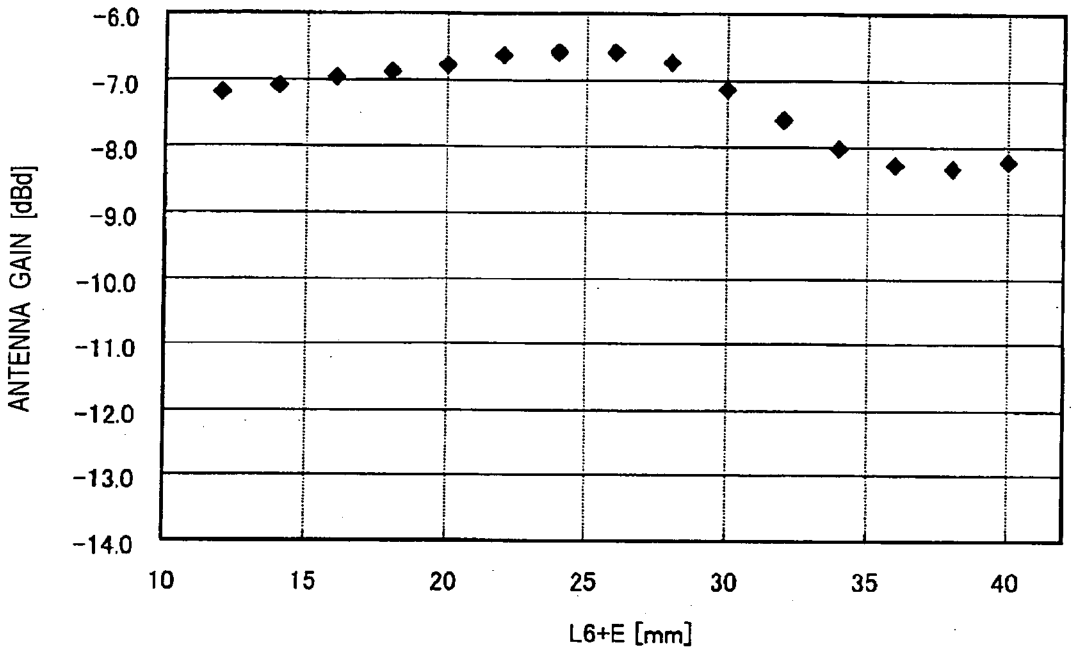

-6.0
-7.0
-8.0
-9.0
-10.0
-11.0
-12.0
-13.0
-14.0
ANTENNA GAIN [dBd]
20
25
30
35
40
45
50
L5+E [mm]

FIG. 11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-9.0
-10.0
-11.0
-12.0
-13.0
-14.0
ANTENNA GAIN [dBd]
10
15
20
25
30
35
40
L6+E [mm]

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EUROPEAN SEARCH REPORT

Application Number
EP 11 00 0784

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	4 May 2011	Kaleve, Abraham

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