Vehicular antenna apparatus and window glass

Appareil d'antenne et vitrage pour véhicule

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Description

TECHNICAL FIELD

[0001] The present invention relates to a vehicular antenna apparatus and a window glass including a glass antenna.

RELATED ART

[0002] Document EP 2 173 008 A1 discloses a high frequency glass antenna for automobiles which is capable of having an improved antenna gain without changing the shape of a defogger. A defogger, an antenna conductor, a feeding portion for the antenna conductor, a grounding conductor, and a grounding-side feeding portion for the grounding conductor are disposed in or on a rear window glass sheet for automobiles, the defogger forms at least one portion of the grounding conductor, and the grounding-side feeding portion is electrically connected to the defogger.

[0003] Document JP 2001 326515 A discloses a non grounding type antenna provided in a blank space part at the upper or lower part of a heating filament provided on the rear window glass of a vehicle. The antenna consists of a first element that is provided with first and second power feeding points at a corner part of the blank space part and defines two T-shaped parts as main filaments, and a seconding element having at least a vertical filament that is subjected to capacitance coupling with the negative electrode bus bar of the heating filament, and respectively connects the first and second elements to the internal lead wire and external lead wire of a coaxial cable.

[0004] Document WO 02/075844 A1 discloses a grounding structure of a vehicle glass antenna that includes: a vehicle window glass; at least one antenna element provided on the window glass that receives at least very high frequency waves; an antenna module provided on the vehicle window glass that is in electrical contact with the antenna element; and a coaxial cable including an outer conductor that is connected to the antenna module. The grounding structure includes a connection that electrically connects the outer conductor to a vehicle body, thus making the vehicle body function as a part of the vehicle glass antenna.

[0005] Document JP 2002 185230 A discloses an isolated balanced antenna to be installed on a window glass of an openable and closable back door of a vehicle, the antenna comprising a first element which has at least one horizontal filament and is connected to a first feeder point provided in an upper part or in a lower corner of the window glass, and a second element which has at least one horizontal filament and is connected to a second feeder point installed near the first one. The horizontal filaments extended from near the feeder points of the elements are capacitively coupled. The length of the second element is set to \( \lambda/4 \) (\( \lambda \): wavelength) or shorter. The first and second elements are connected to inside and outside conductors of an unbalanced coaxial cable, respectively.


[0007] On the other hand, antenna apparatuses in which the outer conductor of a coaxial cable is grounded in the middle of the coaxial cable to the vehicle body are known as, for example, in Japanese Laid-Open Patent Publication No. H6-276008 and Japanese Laid-Open Patent Publication No. 2006-173658.

[0008] In recent years, such vehicle types appear that the inclination angle of the window glass relative to the horizontal plane is small (that is, the surface of the window glass is substantially along the horizontal plane). In a glass antenna provided on such a window glass, the glass surface is oriented upward. Thus, when vertically polarized radio waves such as DAB are to be received, a satisfactory antenna gain is difficult to be ensured.

SUMMARY

[0009] An object of the present invention is to provide a vehicular antenna apparatus and a window glass in which an antenna gain is improved at the low frequency side among the frequency band that can receive radio waves.

[0010] To solve the above-mentioned problem, a vehicular antenna apparatus according to the present invention has the features disclosed in claim 1.

[0011] Further, a window glass according to the present invention is a window glass comprising the above-mentioned glass antenna.

[0012] According to the present invention, even when the inclination angle of the window glass is small, an antenna gain sufficient for receiving vertically polarized radio waves is obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. 1 is a plan view of a glass antenna 100. FIG. 2 is a diagram showing a state that a window glass 23 is attached to a vehicle. FIG. 3 is a plan view of a glass antenna 200. FIG. 4A is a plan view of a glass antenna 300A. FIG. 4B is a plan view of a glass antenna 300B. FIG. 5 shows the data of actual measurement of antenna gain in a case that a grounding point X was varied.
The glass antenna 100 is an antenna of two-pole type that has an antenna conductor and a first feeding section 16 ("feeding section 16", hereinafter) and a second feeding section 17 ("feeding section 17", hereinafter) arranged in a side part region of the window glass 23 and that is provided in a planar manner on the window glass 23. The feeding section 16 and the feeding section 17 constitute a pattern of a pair of feeding points for the antenna conductor. The pair of feeding sections 16 and 17 are arranged with a gap in between in a vertical direction or a horizontal direction. Each antenna conductor is connected to the feeding section 16 and extends in a horizontal direction or a vertical direction.

In FIG. 1, as the element 1, an element 1A linearly extends from the feeding section 16 as a starting point toward the left direction. The element 1A extends to a termination "a" being the end of the element 1. Here, as the element 1, FIG. 3 illustrates an element 1B extending from the feeding section 16 as a starting point toward the left direction and then bends upward and extends linearly.

The outer conductor 72 of the coaxial cable 70 is not limited to a particular one. That is, the connection may be achieved by soldering or alternatively through a connector for easy connection.

As shown in FIG. 1, the vehicular antenna apparatus according to the present invention has a coaxial cable 70 for connecting the pair of feeding sections 16 and 17 to a signal processing unit 80 (e.g., an amplifier) installed on the vehicle body side. One end of the coaxial cable 70 is electrically connected to the feeding section 16, and one end of an outer conductor 72 is electrically connected to the feeding section 17. The method of electrically connecting the pair of feeding sections 16 and 17 to one end of the coaxial cable 70 is not limited to a particular one. That is, the connection may be achieved by soldering or alternatively through a connector for easy connection.

FIG. 2 is a diagram showing a state that the window glass 23 is attached to a vehicle by the stopping piece 75 and the bolt 73. In FIG. 2, the middle part 74 is connected and grounded to the vehicle body through the connector for easy connection. One end of the coaxial cable 70 is electrically connected to the pair of feeding sections 16 and 17 to a signal processing unit 80 (e.g., an amplifier) installed on the vehicle body side. The outer covering of the coaxial cable 70 is not limited to a particular one. That is, the connection may be achieved by soldering or alternatively through a connector for easy connection.

FIG. 3 illustrates an element 1B extending from the feeding section 16 as a starting point toward the left direction and then bends upward and extends linearly. FIG. 4 shows the data of actual measurement of an antenna gain in a case that a conductor length L1A of an element 1A was varied. FIG. 5 shows the data of actual measurement of an antenna gain in a case that a conductor length L2A of an element 2A was varied. FIG. 6 shows the data of actual measurement of an antenna gain in a case that a conductor length L1A of an element 1A was varied. FIG. 7 shows the data of actual measurement of an antenna gain in a case that a conductor length L3 of the element 3 was varied. FIG. 8 shows the data of actual measurement of an antenna gain of a glass antenna with or without an element 2A. FIG. 9 shows the data of actual measurement of an antenna gain in a case that a conductor length L2b of a loop element 2b was varied.
er than or equal to 30° and then one end of the coaxial cable 70 is connected to the pair of feeding sections 16 and 17 and the outer conductor part in the middle of the coaxial cable 70 is connected and grounded to the vehicle body, an antenna gain is obtained that is sufficient for receiving vertically polarized radio waves. The other end of the coaxial cable 70 (the side opposite to the side where the pair of feeding sections 16 and 17 are connected) is connected to the signal processing unit 80.

[0022] In particular, in a configuration that the direction of arrangement of the two feeding sections is vertical and that the direction of the antenna conductor extending from the feeding sections is horizontal, decreasing inclination angle α causes increasing disadvantage in receiving of vertically polarized radio waves. However, according to the present invention, even such a configuration achieves an antenna gain sufficient for receiving vertically polarized radio waves.

[0023] The position where the inclination angle α of the window glass relative to the horizontal plane at the position of the pair of feeding sections 16 and 17 is to be defined is the middle point between the feeding section 16 and the feeding section 17.

[0024] Further, when the conductor length X of the outer conductor from the connection point between the feeding section 17 and one end of the coaxial cable 70 to the connection point between the middle part 74 and the vehicle body is greater than or equal to 75 mm and smaller than or equal to 175 mm or, more preferably, greater than or equal to 100 mm and smaller than or equal to 150 mm, an antenna gain sufficient for receiving vertically polarized radio waves is obtained effectively.

[0025] Meanwhile, as shown in FIG. 1, the glass antenna 100 may be arranged on the window glass 23 provided with a defogger 30 having a plurality of heater wires running in parallel to each other. The antenna conductor and the feeding sections are arranged above the defogger 30.

[0026] The defogger 30 is a pattern of electric heating type having: a plurality of heater wires running in parallel to each other (in FIG. 1, upper heater wires 30a, 30b, and the like are illustrated and heater wires below them are omitted); and a plurality of belt-shaped bus bars for supplying electric power to the heater wires (in FIG. 1, one bus bar 31 is located in a side part on one side of the window glass 23). The plurality of heater wires are arranged on the window glass 23 for example, such as to run in parallel to the horizontal plane (the ground surface) in a state that the window glass 23 is attached to the vehicle. It is sufficient that the number of heater wires running in parallel to each other is two or greater. The plurality of heater wires running in parallel to each other may be connected to each other through a short circuit line. FIG. 1 shows a case that short circuit lines 32 and 33 are provided in the center 40 of the horizontal direction and its both sides (short circuit lines on the left side are not shown). Here, the short circuit lines may be used as adjustment of the antenna gain of the glass antenna. Further, their length may be adjusted appropriately, and one, two, or more, or none short circuit line may be employed. In FIG. 1, at least one bus bar 31 is provided respectively in the left-side region and the right-side region of the window glass 23, and extends in a vertical direction or in an approximately vertical direction of the window glass 23 (the bus bar in the left-side region is not shown).

[0027] The bus bar 31 in the right-side region is connected through a right-side coil 50 to a grounding site such as the vehicle body. The bus bar in the left-side region is connected through a left-side coil (not shown) to the positive electrode side of a DC power supply installed on the vehicle body side. This DC power supply energizes the heater wires. The right-side coil 50 and the left-side coil has a high impedance at least in a predetermined frequency band received by the glass antenna 100, for example, at frequencies of VHF band or higher, and hence suppresses passage of electric signals at the frequencies.

[0028] Further, in addition to the first antenna conductor including the element 1, the glass antenna 100 may include a second antenna conductor including a connection element 2a connected to the defogger 30. When the element 1 runs in parallel to at least one of the second antenna conductor and the defogger 30, the frequency characteristic in the antenna gain of the element 1 can be adjusted. For example, as shown in the figure, it is preferable that the element 1 is close to at least a part of the second antenna conductor.

[0029] As the second antenna conductor, FIG. 1 illustrates a second element ("element 2A", hereinafter) having a loop shape. Since at least one of the element 2A and the defogger 30 runs in parallel to the element 1, the antenna gain on the lower frequency side within the frequency band whose receiving is achieved by the element 1 is improved. Here, as similar embodiments of the element 2A, FIG. 4A illustrates an element 2B, and FIG. 4B illustrates an element 2C. The element 2A in FIG. 1 is an example of arrangement above the element 1A. The elements 2B and 2C in FIGS. 4A and 4B are examples of arrangement below the element 1A. In the elements 2B and 2C, the element 2C has a longer loop circumference.

[0030] The element 2A has: a loop element 2b; and the connection element 2a for connecting the loop element 2b to the uppermost heater wire 30a of the defogger 30. The connection element 2a linearly extends upward from a point b as a starting point and then is connected to the loop element 2b at point c. The loop shape of the loop element 2b may be a quadrangle, a circle, an ellipse, or a polygon. Then, the antenna gain on the lower frequency side within the frequency band whose receiving is achieved by the element 1 is improved.

[0031] Further, the first antenna conductor including the element 1 may also include a third element that is connected to the feeding section 17 and extends in a horizontal direction. When the third element is employed, the frequency characteristic in the antenna gain of the element 1 can be adjusted.
In FIG. 1, as the third element, an element 3 linearly extends from the feeding section 17 as a starting point toward the left direction. The element 3 extends to the termination g being the end of the third element.

Further, the first antenna conductor including the element l may also include a fourth element that is connected to the feeding section 16 and extends in a vertical direction, and may also include a fifth element that is connected to the feeding section 17 and extends in a vertical direction.

In FIG. 1, as the fourth element, an element 4 linearly extends upward from the feeding section 16 as a starting point. Further, as the fifth element, an element 5 linearly extends downward from the feeding section 17 as a starting point. The element 4 extends to the termination h being the end of the fourth element, and the element 5 extends to the termination i being the end of the fifth element.

Even when the fourth element or the fifth element is not employed, radio waves of L band of DAB or higher are receivable. However, when the fourth element and/or the fifth element are employed, the frequency characteristic in the antenna gain for L band of DAB or higher can be adjusted.

Further, as long as the glass antenna has an embodiment illustrated in each diagram, even when tuning is performed on the length or the like of the first antenna conductor and/or the second antenna conductor such that radio waves in the lower frequency band of the dual bands of DAB or the like are received in a state that a predetermined requirement is satisfied, the receiving characteristic for radio waves in the higher frequency band of the dual bands is hardly affected. Similarly, even when tuning is performed on the length or the like of the fourth element and/or the fifth element such that radio waves in the higher frequency band of the dual bands are received in a state that a predetermined requirement is satisfied, the receiving characteristic for radio waves in the lower frequency band of the dual bands is hardly affected. That is, tuning is achieved easily.

Further, the antenna conductor, the feeding section 16, and the feeding section 17 are fabricated by printing and baking a pattern with paste such as silver paste containing a conductive metal, for example, onto the inner surface of the vehicle window glass. However, the method of fabrication is not limited to this. That is, a linear member or a foil-shaped member composed of a conductive substance such as copper may be formed on the inner surface or the outer surface of the vehicle window glass. Alternatively, such a member may be bonded to the window glass with adhesives or the like. Further, such a member may be provided in the inside of the window glass itself.

The shapes of the feeding section 16 and the feeding section 17 and the gap between the feeding section 16 and the feeding section 17 may be determined depending on the shape of the mounting surface of the above-mentioned connector and its gap on the mounting surface. For example, a quadrangular shape such as a square, an approximate square, a rectangle, and an approximate rectangle, as well as a polygonal shape, is preferable for mounting. Alternatively, a circular shape such as a circle, an approximate circle, an ellipse, and an approximate ellipse may be employed. Further, the areas of the feeding section 16 and the area of the feeding section 17 may be identical to or different from each other.

Further, a conductor layer consisting of each antenna conductor may be provided in the inside or on the surface of a film composed of synthetic resin. Then, the synthetic resin film provided with the conductor layer may be provided on the inner surface or the outer surface of the vehicle window glass plate so that a glass antenna may be formed. Alternatively, a flexible circuit board on which each antenna conductor is formed may be provided on the inner surface or the outer surface of the vehicle window glass plate so that a glass antenna may be formed.

Further, a concealment layer may be formed on the surface of the window glass 23. Then, a part or the entirety of the feeding sections and the antenna conductor may be provided on this concealment layer. The concealment layer may be fabricated from a ceramic material such as a black ceramics layer. In this case, when the window glass is viewed from the outside of the vehicle, the part of the antenna conductor provided on the concealment layer is unseen from the outside of the vehicle by virtue of the concealment layer so that a satisfactory design property is achieved in the window glass. In the configuration illustrated in the figure, a part of the feeding sections and the antenna conductor is formed on the concealment layer (between the edges 33a and 33b of the concealment layer and the edges of the window glass 23). Thus, a thin straight line part alone of the conductor is seen from the outside of the vehicle so that a satisfactory design property is obtained.

Meanwhile, in the present invention, as the two broadcasting frequency bands to be received, a first broadcasting frequency band and a second broadcasting frequency band higher than the first broadcasting frequency band are employed. Further, the wavelength in the air at the center frequency of the first broadcasting frequency band and a second broadcasting frequency bands to be received, a first broadcasting frequency band is denoted by λ, and the wavelength in the air at the center frequency of the second broadcasting frequency band is denoted by λ2. Thus, the glass shortening coefficient of wavelength is denoted by k (here, k is 0.54), and λ2=λk is defined. Then, in the embodiment of the above-mentioned glass antenna 100 or the like, the conductor length L1A of the element 1A corresponding to the horizontal component of the element 1 is greater than or equal to (1/12)λg1 and smaller than or equal to (1/4)λg1 or, more preferably, greater than or equal to (1/10)λg1 and smaller than or equal to (1/6)λg1 within a range that the element 1A is not in contact with the conductor located on the left of the element 1A, a preferable result is obtained with respect to improvement in the antenna gain in the first broadcasting frequency band.

Here, when band III (174 to 240 MHz) is set up...
as the first broadcasting frequency band, the center frequency is 207 MHz. Thus, when the antenna gain for band III is desired to be improved, since the speed of radio waves is $3.0 \times 10^8$ m/s and hence $\lambda_g$ at the center frequency 207 MHz is 0.7826 m, it is sufficient that the conductor length $L_{1A}$ of the element 1A is adjusted to be greater than or equal to 70 mm and smaller than or equal to 200 mm or, more preferably, greater than or equal to 80 mm and smaller than or equal to 130 mm.

Further, in the embodiment of the glass antenna 100 or the like, when the conductor length $L_3$ of the element 3 corresponding to the third element is smaller than or equal to $(1/12)\lambda_{g1}$ or, more preferably, smaller than or equal to $(1/14)\lambda_{g1}$ within a range that the element 3 is not in contact with the conductor located on the left of the element 3, a preferable result is obtained with respect to improvement in the antenna gain in the first broadcasting frequency band. Thus, when the antenna gain for band III is desired to be improved, it is sufficient that the conductor length $L_3$ of the element 3 is adjusted to be smaller than or equal to 70 mm or, more preferably, smaller than or equal to 55 mm.

Further, in the present invention, as the two broadcasting frequency bands to be received, a first broadcasting frequency band and a second broadcasting frequency band higher than the first broadcasting frequency band are employed. Further, the wavelength in the air at the center frequency of the second broadcasting frequency band is denoted by $\lambda_{g2}$, the glass shortening coefficient of wavelength is denoted by $k_2$ (here, $k_2=0.74$), and $\lambda_{g2} = \lambda_0 k_2$ is defined. Then, when the length $(L_4+E)$ of a conductor route that joins the termination h being the end of the element 4 to the end of the feeding section 16 is the minimum length that is greater than or equal to 0.17$\lambda_{g2}$ and smaller than or equal to 0.27$\lambda_{g2}$ or, more preferably, greater than or equal to 0.19$\lambda_{g2}$ and smaller than or equal to 0.26$\lambda_{g2}$, a preferable result is obtained with respect to improvement in the antenna gain in the second broadcasting frequency band. The end of the feeding section 16 corresponds to the lower end of the feeding section 16 which is formed in a state that the vehicle center of the vehicle provided with the glass of the glass antenna was set at the center of the turntable. Then, the vehicle was rotated by 360° with projecting radio waves at a predetermined frequency. Then, the average was calculated. The data of antenna gain was measured at every 3° of rotation angle at every 3 MHz for the frequency range of band III (170 to 240 MHz) and at every 1.7 MHz for the frequency range of L band. The elevation angle of the radio wave transmission position relative to the antenna conductor was approximately horizontal (that is, when a plane parallel to the ground surface is defined as elevation angle=0° and the zenith direction is defined as elevation angle=90°, the direction was at elevation angle=0°). The antenna gain was standardized with reference to a half-wavelength dipole antenna such that the half-wavelength dipole antenna should have 0dBd.

Further, when the length $(L_5+E)$ of a conductor route that joins the termination i being the end of the element 5 to the end of the feeding section 17 with the minimum length is greater than or equal to 0.07$\lambda_{g2}$ and smaller than or equal to 0.2$\lambda_{g2}$ or, more preferably, greater than or equal to 0.13$\lambda_{g2}$ and smaller than or equal to 0.19$\lambda_{g2}$, a preferable result is obtained with respect to improvement in the antenna gain in the second broadcasting frequency band. The end of the feeding section 17 corresponds to the upper end of the feeding section 17 being opposite to the feeding section 16. Further, E of $(L_5+E)$ corresponds to the length of one vertical side of the feeding section 17. Thus, when the antenna gain for L band is desired to be improved, it is sufficient that the length $(L_5+E)$ of the conductor route is adjusted to be greater than or equal to 12 mm and smaller than or equal to 30 mm or, more preferably, greater than or equal to 20 mm and smaller than or equal to 28 mm.

[Examples]

Actual measurement results such as the frequency characteristic are described below for a vehicular glass antenna constructed by attaching the glass antenna of the above-mentioned embodiment to the rear window of an actual vehicle.

The antenna gain was measured in a state that the vehicular window glass on which the glass antenna was formed was assembled to a window frame of a vehicle on a turntable at an inclination of approximately 20° relative to a horizontal plane. A connector was attached to the feeding sections and connected through a feeder wire to a network analyzer. Radio waves were projected horizontally onto the window glass. Then, by rotating the turntable, the angle of radio wave projection relative to the window glass was varied.

The measurement of antenna gain was performed in a state that the vehicle center of the vehicle provided with the glass of the glass antenna was set at the center of the turntable. Then, the vehicle was rotated by 360° with projecting radio waves at a predetermined frequency. Then, the average was calculated. The data of antenna gain was measured at every 3° of rotation angle at every 3 MHz for the frequency range of band III (170 to 240 MHz) and at every 1.7 MHz for the frequency range of L band. The elevation angle of the radio wave transmission position relative to the antenna conductor was approximately horizontal (that is, when a plane parallel to the ground surface is defined as elevation angle=0° and the zenith direction is defined as elevation angle=90°, the direction was at elevation angle=0°). The antenna gain was standardized with reference to a half-wavelength dipole antenna such that the half-wavelength dipole antenna should have 0dBd.

Further, when the length $(L_5+E)$ of a conductor route that joins the termination i being the end of the element 5 to the end of the feeding section 17 with the minimum length is greater than or equal to 0.07$\lambda_{g2}$ and smaller than or equal to 0.2$\lambda_{g2}$ or, more preferably, greater than or equal to 0.13$\lambda_{g2}$ and smaller than or equal to 0.19$\lambda_{g2}$, a preferable result is obtained with respect to improvement in the antenna gain in the second broadcasting frequency band. The end of the feeding section 17 corresponds to the upper end of the feeding section 17 being opposite to the feeding section 16. Further, E of $(L_5+E)$ corresponds to the length of one vertical side of the feeding section 17. Thus, when the antenna gain for L band is desired to be improved, it is sufficient that the length $(L_5+E)$ of the conductor route is adjusted to be greater than or equal to 12 mm and smaller than or equal to 30 mm or, more preferably, greater than or equal to 20 mm and smaller than or equal to 28 mm.

[Examples]
The dimensions of the individual sections of the glass antenna 100 measured in FIG. 5 with the unit of mm were as follows.

L1A: 100
L2a (b-c): 70
L2b (path length of c-d-e-f-c): 380
L3: 50
L4: 20
L5: 15

Conductor length of heater wire 30a between point b and bus bar 31 nearest to point b: 115

Here, L* (* indicates a symbol) denotes the conductor length of an element *. The conductor width of each element was 0.8 mm. Each of the feeding section 16 and the feeding section 17 had a square shape with a side length of 10 mm. The gap between the feeding section 16 and the feeding section 17 was 20 mm. The gap between the element 2A and the element 1A was 5 mm.

As seen from FIG. 5, in contrast to that the antenna gain for band III is -18.3dBd (not shown) when the outer conductor of the middle part 74 in the middle of the coaxial cable 70 is not grounded to the vehicle body, the antenna gain for band III was improved when the grounding point X was greater than or equal to 75 mm and smaller than or equal to 175 mm.

FIG. 6 shows the data of actual measurement of antenna gain for a vehicular high-frequency glass antenna constructed by attaching only the elements 1A, 3, 4, and 5 and the feeding sections 16 and 17 among the components in the glass antenna 100 of the embodiment shown in FIG. 1 to the rear window of an actual vehicle. The data shows comparison between the presence and the absence of the element 2A. The vertical axis in FIG. 8 indicates the antenna gain at each frequency measured every 3 MHz in band III. The grounding point X was located at 150 mm at the time of measurement shown in FIG. 8. The other dimensions were similar to those of Example 1.

As shown in FIG. 8, when the element 2A running in parallel to the element 1A is employed, the antenna gain is improved in the lower-frequency range (174 to 210 MHz) of band III. At the higher-frequency range, a satisfactory antenna gain is obtained regardless of the presence or absence of the element 2A.

FIG. 7 shows the data of actual measurement of antenna gain in a case that the conductor length L3 of the element 3 was varied in a vehicular high-frequency glass antenna constructed by attaching the glass antenna 100 of the embodiment shown in FIG. 1 to the rear window of an actual vehicle. The vertical axis in FIG. 7 indicates the average of the antenna gain over the entirety of band III. The grounding point X measured in FIG. 7 was located at 150 mm. The other dimensions were similar to those of Example 1.

As shown in FIG. 7, when the conductor length L3 is smaller than or equal to 70 mm, the antenna gain for band III is improved.

As a result, the average of the antenna gain measured every 3 MHz over the entirety of band III was calculated for the cases that a notch was provided and not provided between the c-f part of the loop element 2b in a vehicular high-frequency glass antenna constructed by attaching the glass antenna 100 of the embodiment shown in FIG. 1 to the rear window of an actual vehicle. The grounding point X at the time of measurement in Example 5 was located at 150 mm. The other dimensions were similar to those of Example 1.

As shown in FIG. 7, when the conductor length L3 is greater than or equal to 70 mm, the antenna gain for band III is improved. Here, the antenna gain data in a case that the conductor length L1A was greater than or equal to 110 mm and smaller than or equal to 200 mm was converged near -6.5dBd. Thus, the data is omitted in FIG. 6.

In each vehicular high-frequency glass antenna constructed by independently attaching the glass antenna 100 of the embodiment shown in FIG. 1 or alternatively the glass antenna 200 of the embodiment shown in FIG.
3 to the rear window of an actual vehicle, the average was calculated for the antenna gain measured every 3 MHz over the entirety of band III. That is, comparison was performed between a case that the element 1A extends in a horizontal direction and a case that the element 1B extends in a vertical direction. The grounding point X at the time of measurement in Example 6 was located at 150 mm. The other dimensions were similar to those of Example 1 (similarly, the conductor length of the element 1B was 100 mm).

[Example 1]

As a result, the average of the antenna gain over the entirety of band III was -6.3dBd for the element 1A and -6.5dBd for the element 1B. That is, no substantial difference was found between the antenna gains of the elements 1A and 1B.

[Example 7]

In each vehicular high-frequency glass antenna constructed by independently attaching the glass antenna 100 of the embodiment shown in FIG. 1 or the glass antenna 300A of the embodiment shown in FIG. 4A or the glass antenna 300B of the embodiment shown in FIG. 4B to the rear window of an actual vehicle, the average was calculated for the antenna gain measured every 3 MHz over the entirety of band III. That is, the loop elements 2A, 2B, and 2C were compared with each other. The grounding point X at the time of measurement in Example 7 was located at 150 mm.

The dimensions of the individual sections of the glass antenna 300A measured in Example 7 with the unit of mm were as follows.

- Conductor length between b-c: 35
- Conductor length between c-d and e-f: 35
- Conductor length between d-e and f-c: 90
- Gap between element 1A and element 2B: 5

The dimensions of the individual sections of the glass antenna 300B measured in Example 7 with the unit of mm were as follows.

- Conductor length between b-g: 35
- Conductor length between c-d and e-f: 35
- Conductor length between d-e and f-c: 210
- Gap between element 1A and element 2C: 5

The other dimensions of the individual sections of the glass antennas 100, 300A and 300B were similar to those of Example 1.

As a result, the average of the antenna gain over the entirety of band III was -6.3dBd for the element 2A, -11.1dBd for the element 2B, and -7.7dBd for the element 2C. That is, it has been found that the configuration of the element 2A in which the second element having a loop shape is arranged above the element 1A is preferable with respect to improvement in the antenna gain in comparison with the configurations of the elements 2B and 2C in which the second element having a loop shape is arranged below the element 1A.

[Example 8]

FIG. 9 shows the data of actual measurement of antenna gain for a vehicular high-frequency glass antenna constructed by attaching the glass antenna 100 of the embodiment shown in FIG. 1 to the rear window of an actual vehicle, in a case that the conductor length L2b corresponding to the circumference of the loop element 2b was varied by simultaneously changing by the same amount the conductor length between c-d and the conductor length between e-f of the loop element 2b. The vertical axis in FIG. 9 indicates the average of the antenna gain over the entirety of band III. The grounding point X at the time of measurement in FIG. 9 was located at 150 mm. The other dimensions were similar to those of Example 1.

As seen from FIG. 9, the antenna gain increases with increasing conductor length L2b corresponding to the circumference of the loop element 2b.

[Example 9]

In a vehicular high-frequency glass antenna constructed by attaching the glass antenna 100 of the above-mentioned embodiment to the rear window of an actual vehicle, the average was calculated for the antenna gain measured every 3 MHz over the entirety of band III and for the antenna gain measured every 1.7 MHz over the entirety of L band. The grounding point X at the time of measurement in Example 9 was located at 150 mm. The other dimensions were similar to those of Example 1.

As a result, the average of the antenna gain over the entirety of band III was -6.5dBd, and the average of the antenna gain over the entirety of L band was -8.6dBd. [Industrial Applicability]

In the present invention, it is preferable that the first and the second frequency bands are assigned, for example, to VHF band of 30 MHz to 0.3 GHz. The applications of the radio waves of VHF band include an FM broadcasting band (76 MHz to 90 MHz) in Japan, an FM broadcasting band (88 MHz to 108 MHz) in the U.S., a television VHF band (90 MHz to 108 MHz, 170 MHz to 222 MHz), the band III (174 MHz to 240 MHz) of DAB, the L band (1452 MHz to 1492 MHz) of DAB, and a DMB (Digital Multimedia Broadcasting) band in South Korea. Further, in the present invention, it is preferable that, for example, the first frequency band is used as VHF band and the second frequency band is used as the lower-frequency side of UHF band of 0.3 GHz to 3 GHz. The applications of radio waves on the lower-frequency side of UHF band include a vehicle-use keyless entry system (300 MHz to 450 MHz) and an 800 MHz band (810 MHz to 960 MHz) for vehicle mobile phones.
1. A vehicular antenna apparatus comprising:

- a window glass (23) attached to a vehicle;
- a glass antenna (100) including a first antenna conductor, and a first feeding section (16) and a second feeding section (17) serving as a pair of feeding points (16, 17) of the first antenna conductor;
- a coaxial cable (70) including an inner conductor (71) connected to the first feeding section (16) and an outer conductor (72) is connected to the second feeding section (17), wherein the first antenna conductor includes a first element (1A, 1B) connected to the first feeding section (16) and extending in a horizontal direction or a vertical direction when viewed opposite to a surface of the window glass (23), and wherein the window glass (23) includes a defogger (30) including a plurality of heater wires (30a, 30b) and a belt-shaped bus bar (31) configured to supply electric power to the heater wires (30a, 30b);
- a grounding member (73, 75) configured to ground to a vehicle body a middle part (74) of the outer conductor (72) of the coaxial cable (70) extending from the pair of feeding points (16, 17) to a signal processing unit (80) installed on the vehicle body, characterized in that the glass antenna (100) includes a second antenna conductor including a loop element (2b) having a loop shape and a connecting element (2a) which connects the defogger (30) and the loop element (2b); and wherein the first element (1A, 1B) is close to at least a part of the second antenna conductor and wherein an inclination angle of the window glass (23) relative to a horizontal plane at a position of the pair of feeding points (16, 17) is greater than or equal to 10° and smaller than or equal to 30°.

2. The vehicular antenna apparatus according to claim 1, wherein a conductor length from the second feeding section (17) to the middle part (74) of the outer conductor (72) is greater than or equal to 75 mm and smaller than or equal to 175 mm.

3. The vehicular antenna apparatus according to any one of claims 1 or 2, wherein the first feeding section (16) and the second feeding section (17) are arranged in a horizontal direction when viewed opposite to the surface of the window glass (23).

4. The vehicular antenna apparatus according to any one of claims 1 to 3, wherein a first broadcasting frequency band and a second broadcasting frequency band higher than the first broadcasting frequency band are employed, a wavelength in the air at a center frequency of the first broadcasting frequency band is denoted by \( \lambda_{g1} \), a glass shortening coefficient of wavelength is denoted by \( g_1 \), and

\[
\lambda_{g1} = \frac{\lambda_0}{k_1}
\]

characterized in that

- a conductor length of the first element (1A, 1B) is greater than or equal to \( \frac{1}{20} \lambda_{g1} \)
- a conductor length of the third element (3) is smaller than or equal to 70 mm.

5. The vehicular antenna apparatus according to any one of claims 1 to 3, wherein a conductor length of the first element (1A, 1B) is greater than or equal to 70 mm and smaller than or equal to 200 mm.

6. The vehicular antenna apparatus according to any one of claims 1 to 5, wherein the first antenna conductor includes a third element (3) extending in the horizontal direction when viewed opposite to the surface of the window glass (23), and wherein the third element (3) is connected to the second feeding section (17).

7. The vehicular antenna apparatus according to claim 6, wherein a first broadcasting frequency band and a second broadcasting frequency band higher than the first broadcasting frequency band are employed, a wavelength in the air at a center frequency of the first broadcasting frequency band is denoted by \( \lambda_{g1} \), a glass shortening coefficient of wavelength is denoted by \( g_1 \), and

\[
\lambda_{g1} = \frac{\lambda_0}{k_1}
\]

characterized in that

- a conductor length of the first element (1A, 1B) is greater than or equal to \( \frac{1}{12} \lambda_{g1} \)
- a conductor length of the third element (3) is smaller than or equal to \( \frac{1}{12} \lambda_{g1} \).

8. The vehicular antenna apparatus according to claim 6, wherein a conductor length of the third element (3) is smaller than or equal to 70 mm.

9. The vehicular antenna apparatus according to any one of claims 1 to 8, wherein the first antenna conductor includes a fourth element (4) extending in a vertical direction when viewed opposite to the surface of the window glass (23), and wherein the fourth element (4) is connected to the first feeding section (16).

10. The vehicular antenna apparatus according to claim 9, wherein a first broadcasting frequency band and a second broadcasting frequency band higher than the first broadcasting frequency band are employed, a wavelength in the air at a center frequency of the second broadcasting frequency band is denoted by \( \lambda_{g2} \), a glass shortening coefficient of wavelength is denoted by \( k_2 \), and

\[
\lambda_{g2} = \frac{\lambda_0}{k_2}
\]

characterized in that

- a conductor length of the first element (1A, 1B) is greater than or equal to \( \frac{1}{12} \lambda_{g1} \).
The vehicular antenna apparatus according to any one of claims 1 to 10, wherein the first antenna conductor includes a fifth element (5) extending in a vertical direction when viewed opposite to a surface of the window glass (23), and wherein the fifth element (5) is connected to the second feeding section (17).

A window glass (23) comprising the glass antenna (100) according to any one of claims 1 to 12.

**Patentansprüche**

1. Eine Fahrzeugantennenvorrichtung, die Folgendes umfasst:

   ein Fensterglas (23), das an einem Fahrzeug befestigt ist;
   
   eine Glasantenne bzw. Scheibenantenne (100), die einen ersten Antennenleiter beinhaltet, und einen ersten Zuführabschnitt (16) und einen zweiten Zuführabschnitt (17), die als Zuführpunktepaar (16, 17) des ersten Antennenleiters dienen;
   
   ein koaxiales Kabel (70), das einen inneren Leiter (71) enthält, der mit dem ersten Zuführabschnitt (16) verbunden ist, und einen äußeren Leiter (72), der mit dem zweiten Zuführabschnitt (17) verbunden ist, wobei der erste Antennenleiter ein erstes Element (1A, 1B) enthält, das mit dem ersten Zuführabschnitt (16) verbunden ist und in einer horizontalen Richtung oder in einer vertikalen Richtung verläuft, wenn es entgegen einer Oberfläche des Fensterglases (23) betrachtet wird, und wobei

   das Fensterglas (23) einen Entnebler bzw. eine Scheibenheizung (30) enthält, die eine Vielzahl an Heizdrähten (30a, 30b) und eine riemenför- mige Sammelschiene (31) beinhaltet, die konfiguriert ist, um die Heizdrähte (30a, 30b) mit elektrischer Energie zu versorgen;
   
   ein Erdungsteil (73, 75), das konfiguriert ist, einen mittleren Teil (74) des äußeren Leiters (72) des koaxialen Kabels (70) an einer Fahrzeugkarosserie zu erden, der sich vom Zuführpunktepaar (16, 17) bis zu einer Signalverarbeitungseinheit (80) erstreckt, die an der Fahrzeugkarosserie installiert ist.

   dadurch gekennzeichnet, dass

   die Glasantenne (100) einen zweiten Antennenleiter beinhaltet, der ein Schlaufenlement (2b) beinhaltet, das eine Schlaufenform aufweist und ein Verbindungselement (2a), das die Scheibenheizung (30) mit dem Schlaufenlement (2b) verbindet; und wobei das erste Element (1A, 1B) sich in der Nähe zumindest eines Teils des zweiten Antennenleiters befindet und wobei ein Neigungswinkel des Fensterglases (23) bezüglich einer horizontalen Ebene an einer Stelle des Zuführpunktepaars (16, 17) größer als oder gleich 10° und kleiner als oder gleich 30° ist.

2. Die Fahrzeugantennenvorrichtung nach Anspruch 1, wobei eine Leiterlänge vom zweiten Zuführabschnitt (17) zum mittleren Teil (74) des äußeren Leiters (72) größer als oder gleich 75 mm ist und kleiner als oder gleich 175 mm.

3. Die Fahrzeugantennenvorrichtung nach irgendeinem der Ansprüche 1 oder 2, wobei der erste Zuführabschnitt (16) und der zweite Zuführabschnitt (17), bei Betrachtung entgegen einer Oberfläche des Fensterglases (23), in einer horizontalen Richtung angeordnet sind.

4. Die Fahrzeugantennenvorrichtung nach irgendeinem der Ansprüche 1 bis 3, wobei ein erstes Ausstrahlungs-Frequenzband und ein zweites Ausstrahlungs-Frequenzband, die höher als das erste Ausstrahlungs-Frequenzband ist, verwendet werden, wobei eine Wellenlänge in der Luft bei einer Mittenfrequenz des ersten Ausstrahlungs-Frequenzbandes mit λ₀₁ gekennzeichnet wird, wobei ein Verkürzungskoeffizient der Wellenlänge für Glas mit k₁ gekennzeichnet wird, und wobei λ₁ = λ₀₁ · k₁ definiert wird, und wobei eine Leiterlänge des ersten Elements (1A, 1B) größer als oder gleich (1/12)λ₁ und kleiner als oder gleich (1/12)λ₁ ist.

5. Die Fahrzeugantennenvorrichtung nach irgendeinem der Ansprüche 1 bis 3, wobei eine Leiter-
Die Fahrzeugantennenvorrichtung nach Anspruch

6. Die Fahrzeugantennenvorrichtung nach irgendeinem der Ansprüche von 1 bis 5, wobei der erste Antenneneleiter ein drittes Element (3) beinhaltet, das sich bei Betrachtung entgegen der Oberfläche des Fensterglasses (23) in horizontaler Richtung erstreckt, und wobei das dritte Element (3) mit dem zweiten Zuführungsschnitt (17) verbunden ist.

7. Die Fahrzeugantennenvorrichtung nach Anspruch 6, wobei ein erstes Ausstrahlungs-Frequenzband und ein zweites Ausstrahlungs-Frequenzband, die höher als das erste Ausstrahlungs-Frequenzband ist, verwendet werden, wobei die Wellenlänge in der Luft bei einer Mittenfrequenz des ersten Ausstrahlungs-Frequenzbandes mit $\lambda_{g1}$ gekennzeichnet wird, und wobei eine Leiterlänge des dritten Elements (3) kleiner als oder gleich $1/(12)\lambda_{g1}$ ist.

8. Die Fahrzeugantennenvorrichtung nach Anspruch 6, wobei eine Leiterlänge des dritten Elements (3) kleiner als oder gleich 70 mm ist.

9. Die Fahrzeugantennenvorrichtung nach irgendeinem der Ansprüche von 1 bis 8, wobei der erste Antenneneleiter ein viertes Element (4) beinhaltet, das sich bei Betrachtung entgegen der Oberfläche des Fensterglasses (23) in vertikaler Richtung erstreckt, und wobei das vierte Element (4) mit dem ersten Zuführungsschnitt (16) verbunden ist.

10. Die Fahrzeugantennenvorrichtung nach Anspruch 9, wobei ein erstes Ausstrahlungs-Frequenzband und ein zweites Ausstrahlungs-Frequenzband, die höher als das erste Ausstrahlungs-Frequenzband ist, verwendet werden, wobei eine Wellenlänge in der Luft bei einer Mittenfrequenz des zweiten Ausstrahlungs-Frequenzbandes mit $\lambda_{g2}$ gekennzeichnet wird, wobei ein Verkürzungskoeffizient der Wellenlänge für Glas mit $k_2$ gekennzeichnet wird, und wobei $\lambda_{g2} = \lambda_{g1} \cdot k_1$ definiert wird, und wobei eine Länge der Leitungsstrecke, die eine Beendigung, die ein Ende des vierten Elements (5) ist, mit einem Ende des zweiten Zuführungsschnitts (17) mit minimaler Länge verbindet, größer als oder gleich $0,07\lambda_{g2}$ und kleiner als oder gleich $0,2\lambda_{g2}$ ist.

11. Die Fahrzeugantennenvorrichtung nach irgendeinem der Ansprüche von 1 bis 10, wobei der erste Antenneneleiter ein fünftes Element (5) beinhaltet, das sich bei Betrachtung entgegen der Oberfläche des Fensterglasses (23) in vertikaler Richtung erstreckt, und wobei das fünfte Element (5) mit dem zweiten Zuführungsschnitt (17) verbunden ist.

12. Die Fahrzeugantennenvorrichtung nach Anspruch 11, wobei ein erstes Ausstrahlungs-Frequenzband und ein zweites Ausstrahlungs-Frequenzband, die höher als das erste Ausstrahlungs-Frequenzband ist, verwendet werden, wobei eine Wellenlänge in der Luft bei einer Mittenfrequenz des zweiten Ausstrahlungs-Frequenzbandes mit $\lambda_{g2}$ gekennzeichnet wird, wobei $\lambda_{g2} = \lambda_{g1} \cdot k_1$ definiert wird, und wobei eine Länge der Leitungsstrecke, die eine Beendigung, die ein Ende des fünften Elements (5) ist, mit einem Ende des zweiten Zuführungsschnitts (17) mit minimaler Länge verbindet, größer als oder gleich $0,17\lambda_{g2}$ und kleiner als oder gleich $0,27\lambda_{g2}$ ist.

13. Ein Fensterglas (23), das eine Glasantenne bzw. Scheibenantenne (100) nach irgendeinem der Ansprüche von 1 bis 12 umfasst.

Reverdications

1. Un dispositif d’antenne de véhicule, comprenant :

une vitre de fenêtre (23) attachée à un véhicule ;

une antenne de vitre (100) incluant un premier conducteur d’antenne, et une première section d’alimentation (16) et une deuxième section d’alimentation (17) servant de paire de points d’alimentation (16, 17) du premier conducteur d’antenne ;

un câble coaxial (70) incluant un conducteur intérieur (71) connecté à la première section d’alimentation (16) et un conducteur extérieur (72) connecté à la deuxième section d’alimentation (17), sachant que le premier conducteur d’antenne inclut un premier élément (1A, 1 B) connecté à la première section d’alimentation (16) et s’étendant dans une direction horizontale ou dans une direction verticale lorsqu’on regarde à l’opposé d’une surface de la vitre de fenêtre (23), et sachant que la vitre de fenêtre (23) inclut un désembueur (30) incluant une pluralité de fils chauffants (30a, 30b) et une barre collectrice (31) en forme de bande configurée pour fournir de l’énergie aux fils chauffants (30a, 30b) ;

un élément de mise à la masse (73, 75) configuré pour relier à la masse à une carrosserie de
Le dispositif d'antenne de véhicule d'après une quelconque des revendications de 1 à 3, sachant que le premier conducteur d'antenne inclut un cinquième élément (3) qui s'étend dans la direction horizontale lorsqu'on regarde à l'opposé d'une surface de la vitre de fenêtre (23), et sachant que le troisième élément (3) est connecté à la deuxième section d'alimentation (17).

7. Le dispositif d'antenne de véhicule d'après la revendication 6, sachant que on emploie une première bande de fréquences de diffusion et une deuxième bande de fréquences de diffusion supérieure à la première bande de fréquences de diffusion, qu'une longueur d'onde dans l'air à une fréquence centrale de la première bande de fréquences de diffusion est désignée par λ, qu'un coefficient de raccourcissement de longueur d'onde dans le verre est dénoté par k, et qu'on définit λg = λk1 · k2, et sachant que une longueur de conducteur du troisième élément (3) est inférieure ou égale à (1/12) λg2.

8. Le dispositif d'antenne de véhicule d'après la revendication 6, sachant que une longueur de conducteur du troisième élément (3) est inférieure ou égale à 70 mm.

9. Le dispositif d'antenne de véhicule d'après une quelconque des revendications de 1 à 8, sachant que le premier conducteur d'antenne inclut un quatrième élément (4) qui s'étend dans la direction verticale lorsqu'on regarde à l'opposé d'une surface de la vitre de fenêtre (23), et sachant que le quatrième élément (4) est connecté à la première section d'alimentation (16).

10. Le dispositif d'antenne de véhicule d'après la revendication 9, sachant que on emploie une première bande de fréquences de diffusion et une deuxième bande de fréquences de diffusion supérieure à la première bande de fréquences de diffusion, qu'une longueur d'onde dans l'air à une fréquence centrale de la deuxième bande de fréquences de diffusion est désignée par λ, qu'un coefficient de raccourcissement de longueur d'onde dans le verre est dénoté par k, et qu'on définit λg = λk1 · k2, et sachant que une longueur de cheminement de conducteur, qui relie une terminaison, étant une extrémité du quatrième élément (4), à une extrémité de la première section d'alimentation (16) avec une longueur minimale, est supérieure ou égale à 0,17 λg2 et inférieure ou égale à 0,27λg2.

11. Le dispositif d'antenne de véhicule d'après une quelconque des revendications de 1 à 10, sachant que le premier conducteur d'antenne inclut un cinquième élément (5) qui s'étend dans la direction verticale lorsqu'on regarde à l'opposé d'une surface de la vitre de fenêtre (23), et sachant que
le cinquième élément (5) est connecté à la deuxième section d’alimentation (17).

12. Le dispositif d’antenne de véhicule d’après la revendication 11, sachant que on emploie une première bande de fréquences de diffusion et une deuxième bande de fréquences de diffusion supérieure à la première bande de fréquences de diffusion, qu’une longueur d’onde dans l’air à une fréquence centrale de la deuxième bande de fréquences de diffusion est désignée par $\lambda_{02}$, qu’un coefficient de raccourcissement de longueur d’onde dans le verre est dénoté par $k_2$, et qu’on définit $\lambda_{g2} = \lambda_{02} \cdot k_2$, et sachant que une longueur de cheminement de conducteur, qui relie une terminaison, étant une extrémité du cinquième élément (5), à une extrémité de la deuxième section d’alimentation (17) avec une longueur minimale, est supérieure ou égale à $0,07 \lambda_{g2}$ et inférieure ou égale à $0,2 \lambda_{g2}$.

13. Une vitre de fenêtre (23) comprenant l’antenne de vitre (100) d’après une quelconque des revendications de 1 à 12.
FIG. 9

CONDUCTOR LENGTH BETWEEN c-d [mm]
(L2b)

AVERAGE GAIN [dBd]

-6.0
-6.2
-6.4
-6.6
-6.8
-7.0
-7.2
-7.4
-7.6
-7.8
-8.0

100 (400)
90 (380)
80 (360)
REFERENCES CITED IN THE DESCRIPTION

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