

9602161-3
16/02/96.
Ipos.

ANTENNA ARRANGEMENT FOR A VEHICLE WINDOW

This invention relates to an antenna arrangement for a vehicle window.

5

It has increasingly become a requirement for equipment within vehicles to be able to transmit and receive in the UHF band, for example, for use in connection with cellular telephone, satellite navigation systems or for other uses.

10

Commonly, to provide for UHF reception, a vehicle is provided with a whip antenna which is in length a multiple of one quarter of the wavelength of the signal to be received. Alternatively, a single vertical stub antenna may be mounted on a window, usually the rear window of the vehicle.

15

A problem with the arrangements described above is that antennas are subject to multipath reception which leads to fast fading of the signal received, which, in the case of an audio signal, causes a general "break-up" in reception. Multipath reception is a consequence of signals being received by the antenna both directly from a transmission source and after reflection from different surfaces. Commonly, such surfaces include walls of building in a built-up urban environment.

20

It is an aim of the present invention to provide an antenna arrangement in which the effect of fast fading upon the quality of the received signal can be reduced.

25

According to a first aspect of the present invention therefore there is provided an antenna comprising

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

2-1215088

receiving elements and a base element the base element acting as a ground plane or as a counterpoise resonant element, the antenna being operable in orthogonal modes when placed on a window of a vehicle.

5

The modes being suitable for providing diversity reception at high frequencies, output signals being sourced selectively from whichever mode provides the stronger output signal. This arrangement at least
10 mitigates, the abovementioned fast fading problems associated with previously used arrangements.

Signals may be fed to and from the modes by means of a hybrid element, which, in operation, permits the modes
15 to be combined without affecting the operation of the antenna itself. The hybrid element may comprise a wound transformer or a conductive ring structure.

The ground plane may be constituted by an edge of
20 the window or alternatively may comprise a conductive ground strip printed on the window. More preferably, a tuned conductive element is provided (to constitute a counterpoise resonant element) instead of the ground plane.

25

The antenna may have two elements symmetrically inclined about a median plane which extends normal to an centrally of the ground plane or the resonant element, as the case may be.

30

In a preferred form, each element comprises a loop of conductive material. A first end of each loop may be connected to the base element, second ends of the loops being interconnected at a common point. In such

This Sheet Has Been Replaced



THIS SHEET HAS BEEN REPLACED

embodiments, signals may be fed to and/or from the antenna at the common point.

5 In an alternative mode of operation of an antenna embodying the invention, the two modes are operable separately or in combination through a hybrid element, signals being connected with the antenna through a circuit operative to combine the two modes in appropriate phase and amplitude to produce, in effect, single antenna
10 of an optimised performance. As will be discussed below, this mode of operation is particularly advantageous when the antenna is to be used to transmit signals.

15 In some circumstances, the two modes may each exhibit resonance two or more at substantially different frequencies, so enabling reception and/or transmission of signals in different frequency bands.

20 An antenna embodying the invention may be used in combination with a switching circuit whereby the antenna is operable as an adaptive antenna system having directional characteristics variable in real time under automatic control.

25 Most advantageously, an antenna embodying the invention is formed as a pattern of conductors printed onto a glass pane. These conductors may be formed at very low cost as part of the process whereby a heater is formed on the pane. In such embodiments, a portion of the
30 pattern may constitute a hybrid element, and a further portion of the pattern may constitute an impedance matching element.

An antenna embodying the invention may be provided

as part of an antenna system in combination with another antenna.

Although it is not possible to use a diversity
5 antenna system for transmission, the antenna of the
present invention is advantageous when used as a
transmission antenna. A major problem associated with
transmission of high-frequency signals from vehicles
arises from the interaction between the antenna and the
10 conductive vehicle body. It has been found in practice
that the nature of the interaction varies substantially
from one model of vehicle to another, with the
consequence that it has not hitherto been possible to
produce a generic transmission antenna optimised for use
15 in a wide range of vehicles.

In a second of its aspects the invention provides a
transmission antenna comprising an antenna according to
the first aspect of the invention, and a combining and
20 tuning circuit, in which the combining and tuning circuit
adjusts the directional and bandwidth characteristics of
the antenna to the vehicle with which it is intended for
use.

25 Thus, a common antenna can be used on a wide range
of vehicles, it being necessary to tailor only the
combining and tuning circuit to the characteristics of
the vehicle.

30 As will be appreciated by those skilled in the art,
a transmission antenna which has two separably operable
orthogonal modes can, with suitable combining and tuning,
exhibit an extremely diverse range of directional,
polarisation and other characteristics. Such a circuit

typically imposes a phase shift or a delay in the signal fed to one of the modes with respect to the other, and which after combination effects a relative difference in the magnitudes of the signals.

5

Embodiments of the invention will now be described in detail, by way of example, with reference to the accompanying drawings in which:

Figures 1a and 1b show schematic views of two forms
10 of antenna applied to a car window;

Figure 2 shows a schematic representation of a circuit including the antenna of Fig. 1 for receiving signals from a remote source;

Figure 3 shows a schematic representation of a
15 circuit including the antenna of Fig. 1 for transmitting signals to a remote source;

Figure 4 shows an antenna being alternative embodiment of the present invention; and

Figure 5 shown an alternative hybrid structure
20 suitable for use in an antenna embodying the invention.

Referring now to the Figures 1 to 3, there is shown in Figure 1 an antenna arrangement 11 embodying the invention applied to a window 12 of a vehicle. The
25 window 12 shown is a rear window of a motor car, although it is to be understood that the invention can be applied to any suitable window of any suitable vehicle.

The window 12 comprises a glass pane 13 which is
30 generally rectangular or trapezoidal (depending upon its application). The pane 13 has top and bottom long edges 14,16 which typically extend approximately horizontally, and two short upright side edges 17,18. The pane 13 may be flat or curved and may lie in a plane (or is curved

relative to a plane) which is substantially vertical or is inclined to the vertical, as is conventional. The pane 13 fits within an opening in a metal body of the vehicle and is sealed against water and air penetration relative to the periphery or the opening with a sealing gasket formed from rubber or similar material, or a suitable adhesive.

The pane 13 typically incorporates a heater, the prime purpose of which is to demist and defrost it, but which may also be used as an antenna for receiving radio signals. The heater comprises a series of parallel, horizontal conductors 19, running between upright bus bars 21,22. The conductors and bars are formed on the inner surface of the glass pane 13 for example, being applied thereto as narrow, flat, printed, conductive strips. The bus bars 21,22 are connected to the d.c. power supply of the vehicle via an operating switch. As is common in vehicle electrical practice, one bus bar is connected to the vehicle earth (i.e. the car body which is directly connected to the negative terminal of the vehicle's battery) and the other bus bar is connected by a lead to a positive supply via an operating switch which may be located for example on the vehicle dashboard.

The heater conductors 19 extend across a major part of the surface area of the window pane but there is a region between the top edge 14 of the window pane 13 and the uppermost heater conductor 19 in which no such heater conductors 19 are provided. In this region there are two straight antenna conductors 23,24 (see Fig. 1a) which are inclined relative to each other having an angle of substantially 90° therebetween. The antenna conductors 23,24 are also inclined relative to the upper edge 14 of

the window 13 at an angle of 45°. The antenna conductors 23,24 are incorporated in or are applied to the inner surface of the pane 13, most advantageously being formed in the same manner as the heater. The antenna conductors
5 23,24 may comprise a 0.4mm wire fixed by adhesive to the surface of the pane, or the conductors may comprise a narrow flat printed conductive strip, say 1 to 1½mm wide.

The conductors 23,24 are relatively short being
10 significantly shorter than the edges of the window frame.

In this embodiment, each of the antenna conductors 23,24 resonates in with respect to a ground plane constituted by the conductive vehicle body adjacent the
15 window aperture. The modes of resonance of the two antenna conductors 23,24 are substantially orthogonal.

In Figure. 1b, an alternative form of antenna arrangement is shown in which ends of the antenna
20 conductors 23,24 remote from the edge 14 of the window are linked by a third conductor 25 forming a loop. It has been found that the provision of such a loop can advantageously modify the impedance and directional characteristics of the antenna which can otherwise not be
25 optimal.

As shown in Figure 2, if the antenna is to be used for reception, its antenna conductors 23,24 can conveniently be connected via a hybrid transformer
30 arrangement 50 to radio reception apparatus to act as an antenna therefor. The operation of the hybrid transformer 50 is such that it combines the output from the two antenna conductors 23,24 to provide two outputs at 52 and 54 respectively which are orthogonal to one

another or have a substantial orthogonal component. Additionally, it is a property of the hybrid arrangement that neither mode interacts with the other.

5 The outputs from each of the antenna conductors 23,24 are added in phase by the transformer arrangement 50 to produce r.f. current vector in the antenna at right angles to the edge 14 of the window or are subtracted out of phase to a net r.f. current vector essentially
10 parallel to the edge 14 of the window. As these two phases of polarisation produce an orthogonal r.f. field, they are totally independent and thus cannot interfere with one another.

15 In use, the stronger one of the two outputs 52,54 can be selected (for example, by a high-speed automatic charge switch controlled by a signal strength detector) to give, effectively, a diversity reception. This can reduce the effect of fast fading due to multipath
20 propagation of the received signals.

Figure 3 shows one circuit arrangement 60 suitable for use when the antenna is being used to transmit signals to a remote site. In this case, the inputs to
25 one of the orthogonal modes of the antenna conductors 23, 24 are fed through a quarter-wavelength delay (in this case, a length of feeder 61 as shown in the figure) with respect to the other mode. This arrangement gives a signal which is circularly or elliptically polarised and
30 this is compatible with a wide range of polarisations of the remote site. As will be readily appreciated, the relative phases and amplitudes of the signals fed to the two modes could be varied in other ways to effect a wide variety of directional and polarisation properties of the

antenna.

In applying to a vehicle an antenna as described in the last-preceding paragraph, the circuit arrangement 61
5 may be designed to account for the effect of the conductive parts of the vehicle. In this manner, the performance of the antenna as a transmitting antenna can be adjusted to offer an optimised performance characteristic.

10

An alternative embodiment of the invention is illustrated in Figure 4. This embodiment may provide a more appropriate impedance over a wider bandwidth as compared with the above described embodiment.

15

It will be appreciated that the vehicle body is only an approximation to a ground plane. In some cases, the deviation from a truly aperiodic ground state is sufficient to cause maloperation of the antenna due to
20 resonances inherent in the body adjacent the antenna. As this may be disadvantageous to the performance of the antenna, an aim of this embodiment is to ameliorate this effect.

25

The antenna comprises a base element 100 being a rectangular conductive strip, intended to be disposed substantially horizontally. A hypothetical median plane A can be defined to intersect the base element 100 at its mid-point, and to extend normal to the base element 100.

30

First and second antenna conductors 110,112 extend from the base element 100 each at an angle of 45° to it. The antenna conductors 110,112 diverge from approximately the intersection of the base element 100 and the median

plane A.

Each of the antenna conductors 110,112 comprises a loop of conductive material. A first part 116 of the loop is electrically connected to the base element 100, as at 114, and extends at 45° from it. A second part 118 of the loop extends parallel to and spaced from the first part 116 to interconnect with the second part 116 of the loop of the other of the antenna conductors at a common point 120. A short bridging element 122 interconnects the first and second parts 116,118 to complete the loop.

The common point 120 constitutes a feed point at which signals may be fed to and from the antenna. A coaxial feeder (not shown) may be used, its screen being connected to the mid-point of the base element 100.

The base element 100 serves as a counterpoise resonant element to the antenna conductors 110,112. This effectively isolates the antenna conductors 110,112 from the effects of the vehicle body.

The following dimensions have been used in one embodiment. Base element: 118mm x 5mm; and antenna conductors each 51mm long, 1.5mm wide, and separated by 1mm. These have been found to be applicable for use with signals in the range 870 to 960 MHZ.

With reference to Figure 5, an alternative hybrid structure is shown which can be conveniently formed as a conductive element printed on the glass in the same process in which the heater and the antenna conductors are formed.

The hybrid structure comprises a conductive ring 130 printed onto the glass pane 13. The length of the ring is equivalent to 1.5 times the wavelength of the signals to be received when propagating in the glass of the window
5 pane 13.

A signal from a first of the modes is fed into the ring through a first feed conductor 132, while a signal from a second of the modes is fed into the ring through
10 a second feed conductor 134. The first and second feed conductors 132, 134 connect to the ring 130 spaced apart by a distance equal to one half of the wavelength of the signals. First and second output conductors 136, 138
15 connect to the ring 130 at, respectively, a point half-way between the first and the second feed conductors 132, 134 and a point opposite the first feed conductor 132.

If it is assumed that mode A is fed through the
20 first feed conductor 132 and that orthogonal mode B is fed through the second feed conductor 134, then it can be shown that (a) the first feed 132 conductor is not affected by signals injected by the second feed conductor 134; (b) the first output 136 carries a signal equivalent
25 to $A+B$; and (c) the second output 138 carries a signal equivalent to $A-B$. This, it will be seen, is functionally equivalent to the circuit of Figure 2.

It is of course to be understood that the invention
30 is not intended to be restricted to the details of the above embodiments which are described by way of example only.

**CLAIMS:**

1. An antenna comprising receiving elements and a base
element the base element acting as a ground plane or as
5 a counterpoise resonant element, the antenna being
operable in orthogonal modes when placed on a window of
a vehicle.
2. An antenna according to claim 1 have two elements
10 angled to one another and to the ground plane.
3. An antenna according to claim 2 in which the two
elements are symmetrically inclined about a median plane,
the median plane intersecting normal to the ground plane
15 or resonant element, as the case may be, at its mid-
point.
4. An antenna according to claim 1 or claim 2 in which
each element comprises a loop of conductive material.
20
5. An antenna according to claim 2 in which a first end
of each loop is connected to the base element, and second
ends of each loop are interconnected at a common point.
- 25 6. An antenna according to claim 4 in which signals are
fed to and/or from the antenna at the common point.
7. An antenna according to any preceding claim in which
the two modes are operable separately or in combination
30 through a hybrid element, signals being connected with
the antenna through a circuit operative to combine the
two modes in appropriate phase and amplitude to produce
a virtual single antenna of an optimised performance.

This Sheet Has Been Replaced

**THIS SHEET HAS BEEN
REPLACED**



8. An antenna according to any one of claims 1 to 5 in which a selection means is provided to arrange for an output signal to be taken from the mode which produces the stronger signal.
- 5
9. An antenna according to any preceding claim in which the two modes are each resonant at two or more substantially different frequencies.
- 10
10. An antenna according to any preceding claim in combination with a combining circuit whereby the antenna is operable as an adaptive antenna system having directional and/or polarisation characteristics variable in real time under automatic control.
- 15
11. An antenna according substantially as herein described with reference to Figures 1 to 3 or to Figures 1a, 1b and 4 of the accompanying drawings.
- 20
12. An antenna according to any preceding claim being formed as a pattern of conductors printed onto a glass pane.
- 25
13. An antenna according to claim 11 in which a portion of the pattern constitutes a hybrid element.
- 30
14. An antenna according to claim 11 or claim 12 in which a portion of the pattern constitutes an impedance matching element.
15. An antenna system comprising an antenna according to any preceding claim in combination with another antenna.
16. A transmission antenna comprising an antenna

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED



14

according to any preceding claim, and a tuning circuit,
in which the tuning circuit tunes the characteristics of
the antenna to the vehicle with which it is intended for
use.

5

his Sheet Has Been ReplacedT



THIS SHEET HAS BEEN
REPLACED