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GB 1472940 A **EP 0875955 A1**
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(54) Abstract Title: **A high frequency antenna integrated in a vehicle**

(57) An antenna comprises first and second antenna elements 64, 66 mounted on a dielectric sheet 62 with a signal connection 70 to the first element 64 and the second element 66 having a connection 72, proximate to that of the first element, which includes a connection to a proximate vehicle-body ground 54. The first and second connections 70, 72 are connected via a balanced transmission line 60 to signal feed means 50. The signal feed means 50 may be an unbalanced transmission line such as a coaxial cable or a signal amplifier. The balanced transmission line 60 may be a twin wire or twin printed conductive line or a twisted wire pair signal feed with a length of about one-half of the centre operational wavelength of the antenna. The first and second elements 64, 66 may be of about the same length and the first element 64 may be arranged to extend in a direction normal to that of the edge of the dielectric sheet 62. The dielectric sheet 62 may be a glass window of a vehicle. The antenna may operate at GHz frequencies.

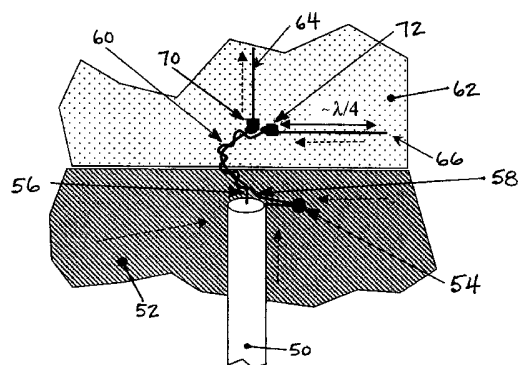


Figure 4

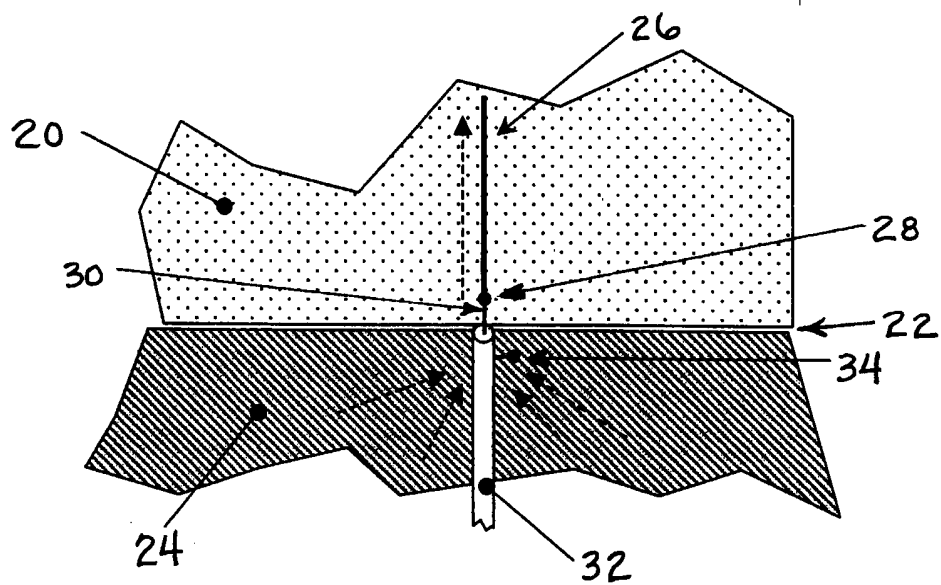


Figure 1

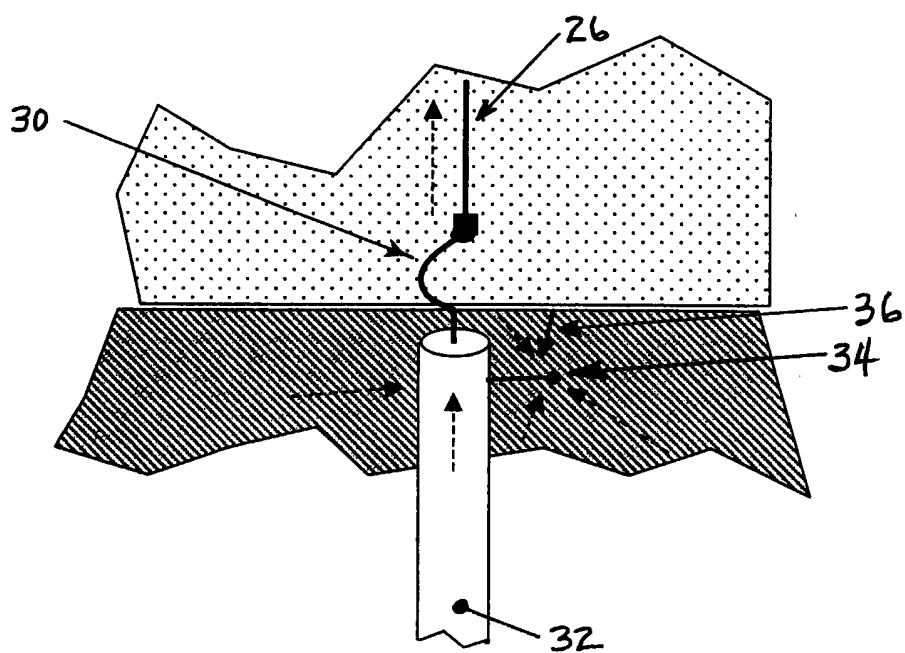


Figure 2

2/3

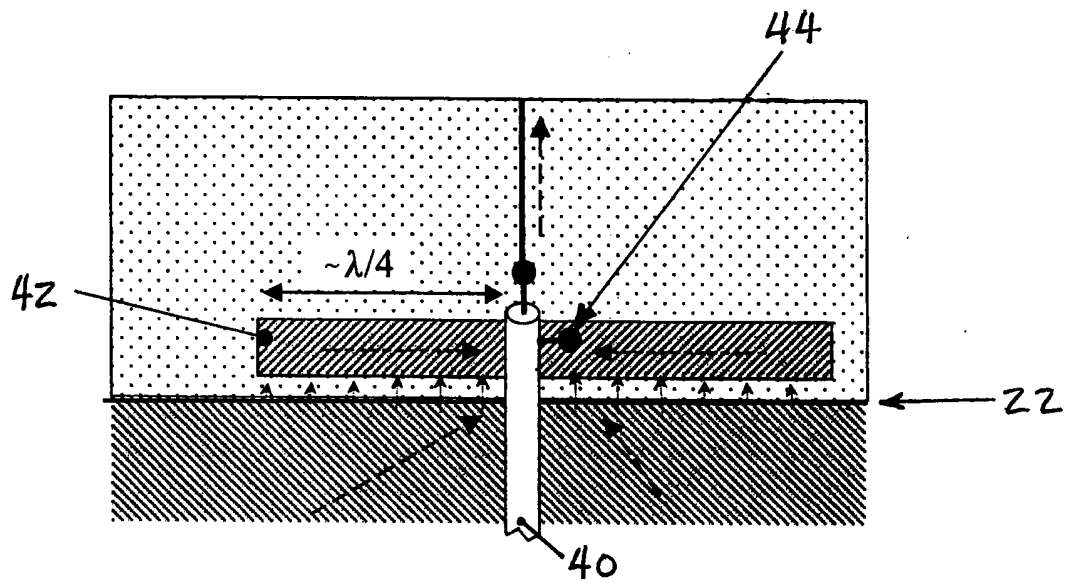


Figure 3

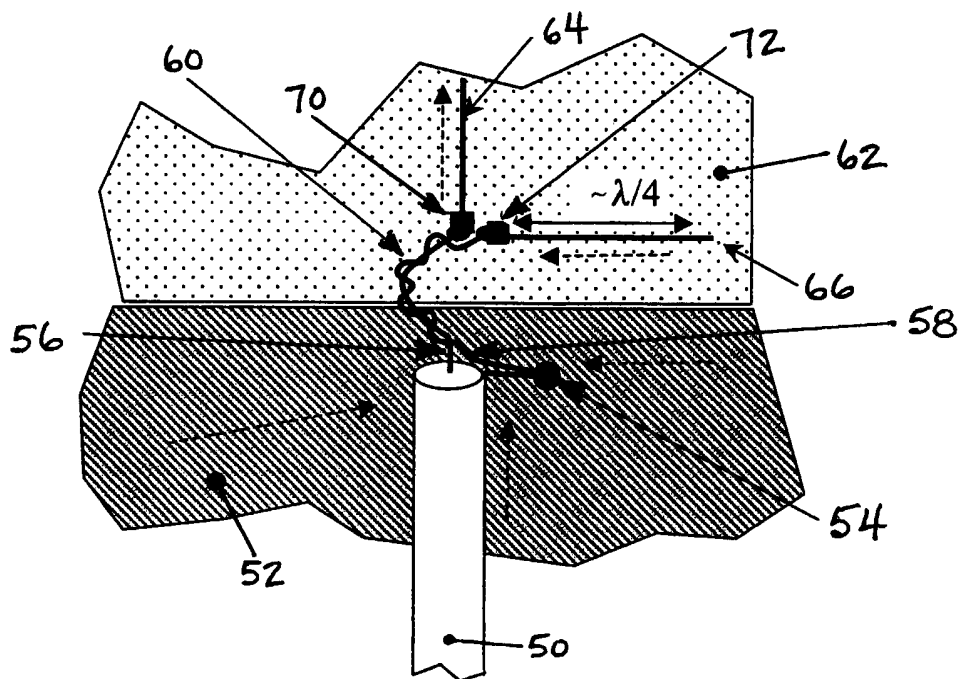


Figure 4

3/3.

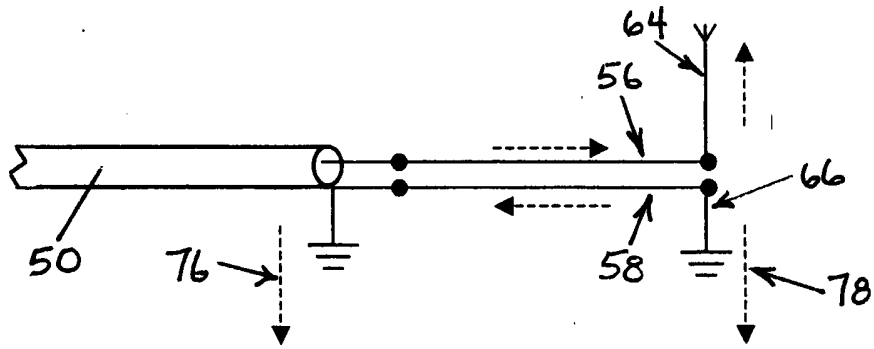


Figure 5

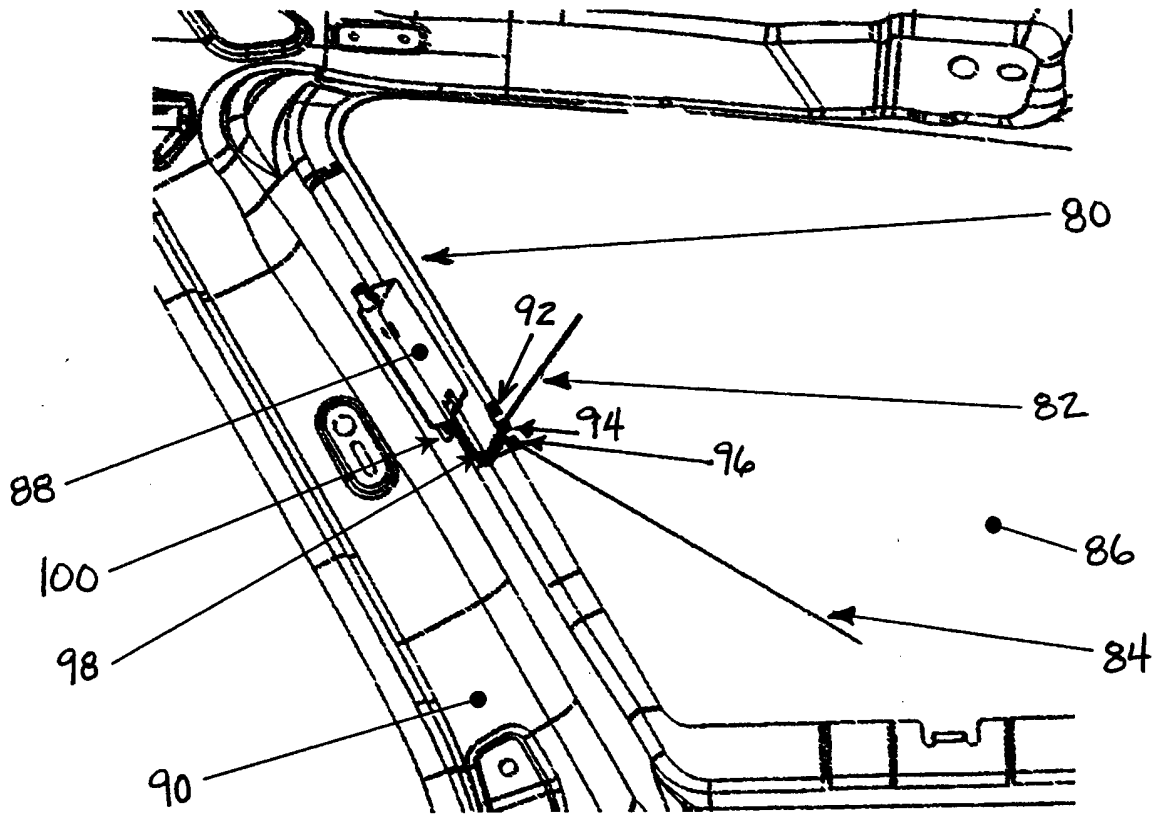


Figure 6

HIGH-FREQUENCY INTEGRATED ANTENNA FOR A VEHICLE

Integrated antennas for radio communication in vehicles have become well-established in recent years. Such antennas often include an antenna element that takes the form of a printed metallic pattern on window glass, though it is also
5 possible to include the antenna element as a part of another vehicle component.

Figure 1 illustrates a typical integrated vehicular antenna. The antenna utilizes a sheet of window glass 20, shown sitting adjacent one edge 22 of a window cavity of a
10 vehicle chassis 24. An antenna element 26 in the form of an elongated linear metallic pattern has been printed onto the window glass 20, and extends inwardly on the glass surface from a signal-connection end 28 of the antenna element. A signal feed line 30 of a coaxial cable 32 (an unbalanced
15 transmission line) extends from the one end ("feed point") of the coaxial cable 32 to connect to the signal-connection end 28 of the antenna element 26. A ground line of the coaxial cable 32 connects to the vehicle chassis 24 at a grounding point 34 close to the edge 22 of the window cavity and to the
20 end of the coaxial cable 32. The antenna element 26 then functions in conjunction with currents (illustrated by arrows in Figure 1) that flow in the vehicle chassis; this forms an unbalanced antenna when used for reception or transmission. To increase antenna gain, the antenna is often formed as an
25 active antenna by adding an amplifier (not shown) at the feed

point. The amplifier is housed in a module that is connected to the chassis earth, with a simple wire extending to the antenna element; this arrangement results in an unbalanced feed line.

5 Normal application of such antennas is for reception of frequency-modulated (FM) and TV broadcast signals. Practical integrated vehicular antennas function well at FM frequencies (ranged around 100 MHz). However, their performance becomes increasingly more limited at higher frequencies due to two
10 factors, both related to the reduced wavelength. Firstly, wavelengths at frequencies in the order of 1 GHz or higher (hereinafter referred to as "GHz frequencies") have lengths that are similar in magnitude to the physical length of feed wire (such as that forming feed line 30 in Figure 1) that
15 connects the amplifier to the antenna element. Secondly, the grounding point 34 is always spaced at a small distance from the edge 22 of the window cavity. For 100 MHz signals this small distance is insignificant, but at GHz frequencies it becomes significant because it approximates the wavelengths
20 of signals at those frequencies. This results not only in the current shown approaching grounding point 34 in Figure 1, but also in additional current (designated 36 in the enlarged view of Figure 2) approaching grounding point 34 from the opposite direction. In the situation illustrated in Figure
25 2, the "net current" to the grounding point 34 is much less than if the current 36 were not present or were minimal. Flow of such "opposite" current 36 results in a significant

reduction in performance of the antenna. For the foregoing reasons, the use of such integrated vehicular antennas is normally limited to signals having a frequency well below GHz frequencies.

5 Increasing pressure is being felt, however, to produce integrated vehicular antennas that can operate in the GHz frequencies in order to accommodate new digital services such as DAB (with a high band of 1452 to 1492 MHz), GPS (at 1575 MHz), and SDARS (US Digital Radio, at 2335 MHz).

10 One solution to the problems described above is shown in Figure 3, in which the end of the coaxial cable 40 extends past the edge 22 of the window cavity, with the ground line of the coaxial cable being secured to a grounding metallic pattern 42 printed on the dielectric. US Patent 5,406,295
15 (Flachglas Aktiengesellschaft) discloses an antenna having this type of construction. In the Figure 3 arrangement, the length of the pattern 42 and the spacing of pattern 42 from the edge 22 of the window cavity are chosen such that the ends and the mid-point of the pattern 42 form open-circuits
20 and a short-circuit, respectively, with the edge 22. This results if the length of pattern 42 is made equal to one-half wavelength of a centre frequency of the signals to be transmitted and/or received, and if the grounding point 44 is connected to a mid-point on the pattern 42. Utilizing the
25 short-circuit between the grounding point 44 and the proximate part of the edge 22 to create "a local earth" avoids difficulties mentioned previously with use of a feed wire.

Though the local-earth concept has been shown to work successfully for GHz frequencies, there are difficulties in using it. Firstly, the costs involved with implementing it are high, particularly since GHz frequencies normally require the use of an active antenna. A related second problem is that a simple wired ground connection is normally preferred for an active antenna. Additionally and tied to the cost, the physical realization of a coaxial connection to glass is inherently difficult to implement and leads to other problems with radio-frequency signals. Finally, a coaxial cable is thicker than a simple wire lead, and extending it onto the surface of window glass can lead to integration problems; for instance, aesthetics may be involved as well as structural issues such as how to extend the cable through trim. There also remains the overriding drawback with the construction in Figure 3 that it is optimized for single-band operation. For dual-band operation, such as required for DAB (Digital Audio Broadcast, with bands centred at 200 MHz and 1500 MHz), the Figure 3 construction resolves the high-band requirement but does not provide means for receiving on the lower second band; for the second band an additional earthing arrangement to the vehicle chassis is required.

The subject invention is directed to addressing the problem of how to create an effective wired connection at GHz frequencies to surfaces of dielectrics such as glass windows, while avoiding the difficulties of radiating feed wires and the need for costly ground patterning on the dielectrics. It

has been found that a solution to this problem lies in using a balanced transmission line, such a twisted wire pair, for connection of a transmission line on the vehicle chassis to signal feed and ground connection points on the dielectric.

5 In one form, the subject invention is a vehicular antenna that includes: a dielectric sheet adapted to be fitted to a vehicle body; a first antenna element on the dielectric sheet, the first element having a signal connection; a second antenna element on the dielectric sheet, the second element
10 providing a local ground for the first element and having a ground connection proximate the signal connection of the first element; and, balanced-transmission-line means for connecting the ground connection to a proximate vehicle-body ground connection, and for connecting the signal connection
15 to a signal feed of a signal-feed means.

Preferably, the antenna also includes the signal-feed means, wherein a ground of the signal-feed means is also connected to the vehicle-body ground connection. More preferably, the signal connection of the first antenna element
20 is at one end of the first antenna element, the first antenna element extending inwardly on the dielectric sheet from the one end, and the ground connection of the second antenna element is at one end of the second antenna element, the second antenna element being at an angle to the first antenna
25 element. The signal-feed means may be an unbalanced transmission line or a signal amplifier means.

The second antenna element may extend generally normal

to the first antenna element.

Preferably, the balanced-transmission-line means is a twin-wire signal feeder, and more preferably, either a twisted pair of wires, a twin-wire line, or a pair of
5 conductors printed onto a flexible circuit board.

Preferably, the antenna includes the signal-feed means, the signal-feed means is a coaxial cable and the balanced-transmission-line means is a twisted pair of wires, wherein: a signal feed line of the coaxial cable is connected through
10 one of the twisted pair of wires to the signal connection of the first antenna element; a signal ground line of the coaxial cable is connected to the vehicle-body ground connection; and, the ground connection of the second antenna element is connected through the other one of the twisted
15 pair of wires to the vehicle-body ground connection.

Preferably, the balanced-transmission-line means is a balanced transmission line having a length approximating one-half of the centre wavelength of a carrier signal in a transmission/reception band of the antenna.

20 The first and second antenna elements may be metallic conductors printed onto the dielectric sheet.

The first antenna element may extend generally normal to an edge of the dielectric sheet.

The first and second antenna elements may be approximately equal in length.
25

The second antenna element may have a length approximating one-quarter of the centre wavelength of a carrier

signal in a transmission/reception band of the antenna.

The dielectric sheet may be a glass sheet adapted to be fitted into an opening in the vehicle body.

Another form of the subject invention is a vehicle
5 having a body with an opening into which the vehicular antenna of any one of the preceding claims has been fitted.

Preferred features of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

10 Figure 1 is an illustration of a conventional vehicular antenna that includes a connection between an antenna-element pattern on a window surface and a coaxial cable extending on the vehicle chassis for carrying signals to/from the antenna element;

15 Figure 2 is an enlarged illustration of the same arrangement as in Figure 1, but showing additional currents that flow to a grounding point on the vehicle chassis when the antenna is used to transmit/receive GHz frequencies;

Figure 3 is an illustration of a third conventional
20 vehicular antenna in which a coaxial cable extends onto the window surface, with a grounding wire of the cable connecting to a grounding metallic pattern on the window surface;

Figure 4 is an illustration of a preferred embodiment of the vehicular antenna of the subject invention, the antenna
25 including a twisted wire pair (functioning as a balanced transmission line) connecting to antenna elements on a window surface;

Figure 5 is a schematic drawing of an equivalent circuit to the antenna shown in Figure 4; and,

Figure 6 is a view of a side quarter window of a vehicle and a dual-band DAB screen antenna that has been fitted to
5 that window.

A preferred embodiment of the subject invention is shown in Figure 4. As with the conventional arrangements shown in Figures 1 and 2, one end of the coaxial cable 50 terminates on the vehicle chassis 52. (It should be noted that coaxial
10 cable is just one type of unbalanced transmission line that is used for carrying antenna signals within vehicles. The subject invention has application to all such transmission lines.) The ground line of coaxial cable 50 is connected to a grounding point 54 on the chassis 52. (Although not shown
15 in the Figure 4 embodiment, any amplifier module fitted to the end of the coaxial cable 50 would have its ground line connected to the grounding point 54.) The signal feed line 56 of the cable 50 (or a signal feed line of an amplifier module, if used) forms, with a ground wire 58 connected to
20 the grounding point 54, a twisted wire pair 60.

The window glass 62 sits in a cavity on the chassis 52, and has printed thereon a metallic pattern 64 that acts as an antenna element. The metallic pattern 64 is similar in shape and position to the metallic pattern 26 shown in Figure 2. A
25 second printed metallic pattern 66, acting as an earth stub, also extends on the window glass 62 at a right angle to the metallic pattern 64. The metallic patterns 64 and 66 are

positioned such that a feed connection point 70 at one end of the metallic pattern 64 is close to a ground connection point 72 at one end of the earth stub 66. The twisted wire pair 60 is connected to the pair of antenna elements on the window glass 62 by connecting the signal feed line 56 and the ground wire 58 to the connection points 70 and 72, respectively.

The use of the twisted wire pair 60 provides a local earth on the window glass 62 by tuning the earth-stub 66 to give a low impedance at the feed connection point 70; the tuning is accomplished by making the length of earth stub 66 equal to an odd integral number of quarter wavelengths of the centre frequency of signals to be received and/or transmitted by the antenna. Although such an arrangement might appear to be similar to the arrangement of Figure 3, there are subtle differences that result from the twisted wire pair 60 being what is termed an "unscreened balanced transmission line". Used alone and without the presence of the earth stub 66, the twisted wire pair 60 (or any other balanced transmission line) could give the same problems as encountered in using a long feed wire (Figures 1 and 2), in particular, the problem of acting as a signal radiator. However, the presence of the earth stub 66, the proximity of the feed connection point 70 to the ground connection point 72, and the use of the twisted wire pair 60 or other form of balanced transmission line all ensure that returning current is properly collected and returned to the grounding point 54 with minimal radiation en route.

An equivalent circuit to the structure of Figure 4 is shown in Figure 5. In the ideal arrangement, the current flowing on each wire 56, 58 of the twisted wire pair is equal in magnitude but opposite in direction. As such, even though
5 no shielding exists, there is no net radiation from this twin-wire feed arrangement. However, this requires that the current flowing on the signal antenna element 64 is balanced by the current on the earth stub 66. This occurs when the chassis earth current 76 (equivalent to all the current
10 approaching the grounding point 54 in Figure 4) mirrors the current 78 on the earth stub 66 -- that is, there is no current flow back to an unbalanced transmission line. With respect to Figure 4, this is achieved by connecting the earth-stub grounding point (the chassis-side end of the
15 ground wire 58) to the chassis grounding point 54 for the unbalanced trans-mission line (coaxial cable 50), or by connecting them to the chassis to be very close to each other. If this condition is not satisfied, the currents flowing on the twisted wire pair 60 (56, 58) will differ from
20 each other and the twisted wire pair will radiate. Although the discussion has been on a twisted wire pair, it is true of all balanced transmission lines, other examples of which are: twin-wire line (wires held a fixed distance apart by being within moulded plastic or another dielectric, or by being
25 held at a fixed separation distance by a former), and line formed by metallic printing on a flexible circuit material.

Figure 5 makes evident that there is a potential

mismatch between the impedances of the pair of antenna elements 64 and 66, the balanced transmission line 56, 58, and the unbalanced transmission line (coaxial cable 50). For instance, most coaxial cables and antennas have impedances of 5 50 to 75 ohms while the impedance of a parallel-transmission line is 200 ohms. To improve the efficiency of the parallel-transmission line it is desirable to make the length of the signal feed wire 56 an integral number of half wavelengths of the operating frequency; in such case, it is only necessary 10 then to make the impedances of the pair of antenna elements and the unbalanced transmission line to be of similar value.

Although the description thus far has concentrated on "screen antennas", i.e. printed metallic patterns, with connection to an amplifier or coaxial cable, the invention is 15 equally applicable to other antenna structures where the antenna element is formed on a dielectric panel and requires a chassis for grounding; for instance, the antenna could be a film antenna placed behind an injection-moulded body panel.

Illustrated in Figure 6 is a version of the antenna of 20 the subject invention that is installed at a side quarter window of a vehicle. This is a dual-band DAB screen antenna formed using three metallic patterns 80, 82, 84 printed onto the glass 86 of the side quarter window. A signal-feed amplifier module 88 is fixed to the vehicle chassis 90. The 25 first, second and third printed patterns 80, 82, 84 are electrically connected at respective first, second and third connection points 92, 94 and 96 to respective first, second

and third wires of a 3-wire twisted-wire feeder line 98, the other end of which is connected to the amplifier module 88. At least the connection points 92 and 94 are made proximate.

The first printed pattern 80 is an earth stub that is
5 adjusted to provide a local earth reference for the signal-feed connection point 94 of the second printed pattern 82. This local earth is connected through the first wire of the twisted-wire feeder line 98 to the chassis earth point 100, to which the ground of the amplifier module 88 is also
10 connected. The second printed pattern 82 thereby forms an antenna for the higher DAB frequency band (centred on 1500 MHz). The length of the second wire of the feeder line 98, which wire connects to the signal-feed connection point 94, is adjusted to be approximately one-half of the wavelength at
15 1500 MHz.

For operation at the lower DAB frequency band (centred on 200 MHz), the longer third printed pattern 84 is used. The earth stub 80 is too short to be effective in providing a local earth reference for the third printed pattern 84, and
20 the third wire of the feeder line 98 therefore acts in an unbalanced mode. However, such unbalance has only a minor effect on performance of the 200-MHz antenna since the third wire of the feeder line 98 is relatively short compared to the wavelength of a 200-MHz signal. (This is also discussed
25 above with reference to Figures 1 and 2.) The 200-MHz antenna is thus acting in a conventional manner.

The amplifier module 88 contains separate amplifiers for

each of the two frequency bands, one amplifier using the inputs from the first and second wires of the feeder line 98, and the other amplifier needing only input from the third wire of the feeder line 98. The 200-MHz amplifier uses a
5 filter at its input (high-impedance) to prevent any current flow at 1500 MHz; this prevents the third wire having any effect on the first and second wires, which need to operate as a "twin-wire" feed at 1500 MHz.

While the present invention has been described in its
10 preferred embodiments, it is to be understood that the words which have been used are words of description rather than limitation, and that changes may be made to the invention without departing from its scope as defined by the appended claims.

15 Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features.

The text of the abstract filed herewith is repeated here
20 as part of the specification.

A vehicular antenna for operation at GHz frequencies includes a dielectric member to be fitted to a vehicle body. A signal antenna element and, at an angle thereto, a ground antenna element extend on the dielectric member. The signal
25 antenna element extends inwardly on the dielectric member from a signal-connection end, and that end is proximate a ground-connection end of the ground antenna element. The

antenna further includes a balanced transmission line for connecting the ground-connection and signal-connection ends of the respective antenna elements to a ground connection on the vehicle body and a signal feed connection, respectively.

CLAIMS:

1. An integrated vehicular antenna comprising:
a dielectric sheet adapted to be fitted to a vehicle body;
a first antenna element on the dielectric sheet, the first element having a signal connection;
a second antenna element on the dielectric sheet, the second element providing a local ground for the first element and having a ground connection proximate the signal connection of the first element; and,
balanced-transmission-line means for connecting the ground connection to a proximate vehicle-body ground connection, and for connecting the signal connection to a signal feed of a signal-feed means.
2. The vehicular antenna of claim 1, also comprising the signal-feed means, wherein a ground of the signal-feed means is also connected to the vehicle-body ground connection.
3. The integrated vehicular antenna of claim 2, wherein:
the signal connection of the first antenna element is at one end of the first antenna element, the first antenna element extending inwardly on the dielectric sheet from the one

end;

the ground connection of the second antenna element is at one end of the second antenna element, the second antenna element being at an angle to the first antenna element.

4. The vehicular antenna of claim 2 or 3, wherein the signal-feed means is an unbalanced transmission line.

5. The vehicular antenna of claim 2 or 3, wherein the signal-feed means is a signal amplifier means.

6. The vehicular antenna of any preceding claim, wherein the second antenna element extends generally normal to the first antenna element.

7. The vehicular antenna of any preceding claim, wherein the balanced-transmission-line means is a twin-wire signal feeder.

8. The vehicular antenna of claim 7, wherein the twin-wire signal feeder is a twisted pair of wires.

9. The vehicular antenna of claim 7, wherein the twin-wire signal feeder is a twin-wire line.

10. The vehicular antenna of claim 7, wherein the twin-wire signal feeder is a pair of conductors printed onto a

flexible circuit board.

11. The vehicular antenna of claim 4, wherein the unbalanced transmission line is a coaxial cable and the balanced-transmission-line means is a twisted pair of wires, and wherein:

a signal feed line of the coaxial cable is connected through one of the twisted pair of wires to the signal connection of the first antenna element;

a signal ground line of the coaxial cable is connected to the vehicle-body ground connection; and,

the ground connection of the second antenna element is connected through the other one of the twisted pair of wires to the vehicle-body ground connection.

12. The vehicular antenna of any preceding claim, wherein the balanced-transmission-line means is a balanced transmission line having a length approximating one-half of the centre wavelength of a carrier signal in a transmission/reception band of the antenna.

13. The vehicular antenna of any preceding claim, wherein the first and second antenna elements are metallic conductors printed onto the dielectric sheet.

14. The vehicular antenna of any preceding claim, wherein the first antenna element extends generally normal to

an edge of the dielectric sheet.

15. The vehicular antenna of any preceding claim, wherein the first and second antenna elements are approximately equal in length.

16. The vehicular antenna of any preceding claim, wherein the second antenna element has a length approximating one-quarter of the centre wavelength of a carrier signal in a transmission/reception band of the antenna.

17. The vehicular antenna of any preceding claim, wherein the dielectric sheet is a glass sheet adapted to be fitted into an opening in the vehicle body.

18. A vehicle having a body with an opening into which the vehicular antenna of any one of the preceding claims has been fitted.

19. A vehicular antenna substantially as herein described with reference to and as shown in the accompanying drawings.

Application No: GB0507993.4

Examiner: Mr John Watt

Claims searched: 1 - 19

Date of search: 14 March 2006

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	DE 2429628 A1 (MEINKE) see figs.7 - 10
A	-	DE 3619704 A1 (LINDENMEIER ET AL) see figs.1 - 2
A	-	JP 2004172906 A (FUJITSU) see figs.1 - 12
A	-	JP 2002319815 A (EE C II TEC ET AL) see figs.1 - 5
A	-	GB 1472940 A (TOYOTA) see fig.2
A	-	EP 0875955 A1 (FORD) see whole document

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^x :

H1Q

Worldwide search of patent documents classified in the following areas of the IPC

H01Q

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI