

DESCRIPTION

BROADBAND ANTENNA ARRANGEMENT

5 TECHNICAL FIELD

The present invention relates to the field of antenna technology. It relates in particular to a broadband antenna arrangement as claimed in the precharacterizing
10 clause of claim 1.

PRIOR ART

The geometric dimensions of antennas are closely
15 related to the wavelength of the waves which are intended to be emitted or received via the antennas. Frequently - for example in the case of portable radio appliances - the space available for the antennas is restricted, so that the antennas should be designed to
20 be as compact as possible, without any restriction to the bandwidth and the efficiency.

A number of proposals have already been made in the past (US-A3,295,137 or US-A-3,508,271) for folded
25 monopoles to be used as compact antennas, which are arranged in the form of a hairpin above an electrically conductive base plane, with one end being conductively connected (grounded) to the base plane, while the other end is used as a feed point independently of the base
30 plane.

The characteristic properties of unfilled and filled monopoles folded two or more times have also been investigated in an article by B. J. Lamberty, "A Class
35 of Low Gain Broadband Antennas", 1958 IRE Wescon Convention Report, pp. 251 - 259 (August 1958).

More recently, folded monopoles have been used to allow

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a radio link for portable computers (in this context, see US-A-6,054,955) or to provide wire-free price labeling systems via LANs (in this context, see US-A-5,668,560).

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The vehicle antennas in the railroad field are subject to particular requirements. Local antennas such as these should be designed in individual cases not only for a frequency range from 870 MHz to 2170 MHz with a
10 VSWR of < 2 , thus being suitable for the GSM 900, GSM 1800 and UMTS ranges. They should also be compact and mechanically robust in order to allow a reliable radio link despite the vibration, bugs and other environmental influences. Furthermore, owing to
15 possible contact with the overhead wire on electrified sections, local antennas must, in accordance with the relevant test instructions, withstand in particular voltages of 16.6 kV and currents of 40 kA, in which case a voltage of no more than 60 V may occur at the RF
20 connection in order that personnel in the locomotive are not endangered by the downward feed cable. Examples of local antennas such as these are the K70 20 21 type antennas for the frequency range from 410 to 470 MHz, and the 742 325 type for the frequency range from 870
25 to 2170 MHz from the Kathrein Company. A broadband vehicle antenna which is resistant to heavy currents is also described in DE-A1-199 24 349.

DESCRIPTION OF THE INVENTION

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One object of the invention is to provide a broadband antenna arrangement which is not only physically compact but is also mechanically robust and, in particular, is suitable for use as a vehicle antenna in
35 the railroad field. A further aim is for the capability to use the antenna arrangement in a frequency range from about 800 MHz up to several GHz.

The object is achieved by the totality of the features of claim 1. The essence of the invention is to use an antenna element which is in the form of a monopole and extends at a distance above a planar, electrically
5 conductive base plate in a longitudinal direction essentially parallel to the base plate between two opposite ends of the antenna element and is electrically conductively connected at the first end of the base plate, and has a feed point, which is isolated
10 from the base plate, at the second end, via which feed point the antenna element can be connected to a radio-frequency device.

According to a first preferred embodiment, a high
15 degree of mechanical robustness and a high current carrying capacity as well as simplified assembly are achieved in that the antenna element is in the form of a solid metal plate which has a constant thickness transversely with respect to the longitudinal direction
20 and is composed of aluminum or an aluminum alloy, in that the antenna element has a foot at the first end, in that the antenna element is attached to the base plate by the foot, and in that the foot has at least one threaded hole or attachment hole, through which the
25 foot is screwed to the base plate.

The design and assembly are particularly simple and functionally reliable if, according to a second preferred embodiment, a coaxial plug connector which is
30 at right angles to the base plate and in particular is in the form of a connecting socket is arranged on the lower face of the base plate in the area of the feed point, with its outer conductor being electrically conductively connected to the base plate and its inner
35 conductor being electrically conductively connected through an opening in the base plate to the feed point of the antenna element, and if the connection between the feed point and the inner conductor of the coaxial

plug connector is designed to be detachable, in which case an electrically conductive connecting pin which projects downwards at right angles to the base plate is arranged at the feed point of the antenna element and
5 fits in a socket which is fitted to the inner conductor of the coaxial plug connector.

The connecting pin may in this case be integrally formed on the antenna element. It is then also machined
10 out during the mechanical machining of the antenna element. However, it may also be in the form of a separate push-in pin, and may be pushed into a corresponding opening in the antenna element. This has the advantage that the connecting pin may be composed
15 of a different material, which is optimized for making contact, and may be produced more easily as a turned part.

In order to protect the antenna element against
20 damaging environmental influences, it is advantageous for the antenna element to be covered on the outside by a removable shroud, which is detachably connected, in particular screwed, to the base plate.

25 According to a further preferred embodiment of the antenna arrangement according to the invention, the antenna element has a bar-like base element which runs in the longitudinal direction and to which additional resonant structures are fitted, distributed non-
30 uniformly transversely with respect to the longitudinal direction, in which case the resonant structures comprise in particular elements which are integrally formed on the base element and are oriented at right angles to the base plate.

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The resonant structures may in this case be rectangular and/or angled, and may have inclined and/or rounded corners.

Further embodiments can be found in the dependent claims.

5 BRIEF EXPLANATION OF THE FIGURES

The invention will be explained in more detail in the following text using exemplary embodiments and in conjunction with the drawing, in which:

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Figure 1 uses a number of figure elements to show a longitudinal section (Figure 1a), in a view from the front (Figure 1b) and an enlarged detail of the plug-in connection (Figure 1c) of an antenna arrangement according to a first preferred exemplary embodiment of the invention;

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Figure 2 uses a number of figure elements to show a longitudinal section (Figure 2a), in a view from the front (Figure 2b) and a view from underneath (Figure 2c) of the antenna element shown in Figure 1;

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Figure 3 shows a view from above of the base plate of the antenna arrangement shown in Figure 1;

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Figure 4 shows an enlarged side view of the connecting pin at the feed point of the antenna arrangement shown in Figure 1;

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Figure 5 shows a longitudinal section through an antenna arrangement according to a second preferred exemplary embodiment of the invention;

Figure 6 shows a side view of the antenna element of the antenna arrangement shown in Figure 5;

Figure 7 shows a plan view from underneath of the base plate of the antenna arrangement shown in Figure 5;

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Figure 8 shows a perspective illustration of an antenna arrangement according to a third preferred exemplary embodiment of the invention, with angled and inclined resonant elements; and

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Figure 9 shows the relationship between the return loss and the frequency for the antenna arrangement shown in Figure 8.

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WAYS TO IMPLEMENT THE INVENTION

The various figure elements in Figure 1 show different views of the first preferred exemplary embodiment of an antenna arrangement according to the invention. The figure element 1a shows a longitudinal section through the antenna arrangement 10, which is formed on an electrically conductive base plate 18 and is covered by a shroud 11 in the form of a cup. The shroud 11 is preferably composed of a fiber-reinforced plastic and is screwed by means of four screws 20 to the base plate 18, with these screws being screwed into corresponding threaded holes 34 (Figure 3) in the base plate. In the illustrated exemplary embodiment, the shroud 11 has a flange-like edge with a circumferential groove, in which a sealing ring 76 is inserted, in order to improve the sealing of the internal area from the external area.

As can be seen from Figures 1a and 3, the essentially rectangular base plate 18 has a raised mounting platform 32 in the central area, adjacent to which on the transverse faces there are two attachment flanges

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31, 31', in each of which two attachment holes 33 are provided, at the corners. The base plate 18 and thus the entire antenna arrangement 10 can be tightly screwed by means of the four attachment holes 33 to a planar outer surface of a vehicle (a locomotive). Electrical access to the antenna arrangement 10 is gained through an opening in the outer surface of the vehicle, through which a coaxial antenna socket 17, which is arranged on the lower face of the base plate 18, projects into the interior of the vehicle, where it can be connected to a coaxial plug on an antenna cable. The connecting socket 17 is sealed on the outside by a sealing ring 16 which surrounds it and is inserted into an annular groove 38 on the lower face of the base plate 18. When not connected, the coaxial connecting socket 17 can be protected by a protective cap 19

The central component of the antenna arrangement 10 is an antenna element 14 which acts as a monopole, three different views of which are shown in Figure 2. The integral antenna element 14 is composed of a semi-hard aluminum alloy. It may be machined from a corresponding metal plate. However, it may also be cast in this shape. It is also feasible for a mount body to be sprayed from a plastic, which is then provided with an electrically conductive surface coating. The antenna element 14 has a foot 22 with a thickness of about 5 mm in the form of a rectangular plate with rounded corners and external dimensions of about 30 mm x 38 mm (Figure 2c). The antenna element 14 is inserted with the foot 22 into a corresponding milled area 35 in the mounting platform 32 (Figure 3), and is screwed to the base plate 18 by means of four threaded holes 30 on the foot 22 and through-holes 36 in the base plate 18. The upper face of the foot 22 is in this case adjacent, without any step, to the upper face of the mounting platform 32, so that, for antenna purposes, the foot 22 is part of the base plate 18. A bar-like base element

27, which extends parallel to the foot plane and at a distance from it, is arranged above the foot 22 (underneath the foot in the illustration rotated through 180° shown in Figure 2) of the antenna element 14. The base element 27 has a square cross section with a side length of about 8 mm. It can withstand a current surge of 40 kA for a duration of 100 ms without any problems. At one of its ends, the base element 27 is connected by a vertical section 26 to the foot 22, and is thus grounded.

An attachment 29 which points towards the foot 22 and in which a blind hole 24 is incorporated from the foot 22 is arranged at its other end. A rectangular resonant structure 28 with a square cross section (8 mm side length) and the height of 2 mm is arranged on the upper face of the base element 27. The blind hole 24 is accessible from the outside through a concentric through-hole 23 with a larger diameter in the foot 22. A connecting pin 13, which is in the form of a push-in pin and is composed of brass (Figure 4), is pushed with its foot 39 into the blind hole 24, so that it projects into the through-hole 23 in the foot 22 and can be made contact with from underneath (feed point 12) through a corresponding through-hole 37 in the base plate 18 (Figure 3). This is done by means of the inner conductor 74 of the coaxial connecting socket 17, at whose upper end a longitudinally slotted socket 21 is arranged for holding the connecting pin 13 (Figure 1c). The connecting socket 17 is attached by means of four screws, which are screwed into the threaded holes 30 in the foot 22 of the antenna element 14 through the through-holes 36 in the base plate 18. The outer conductor of the coaxial connecting socket 17 is thus at the same time conductively connected to the base plate 18. This configuration results in a functionally reliable and compact connection, which is particularly simple to assemble, between the antenna element 14 and

the coaxial connecting socket 17. As can be seen from Figure 2, the blind hole 24 is connected to the external area through a horizontal connecting channel 25. The connecting channel 25 ensures that, when the connecting pin 13 is pushed in, the expanding air can escape without causing any damage from the remaining volume of the rest of the blind hole 24, when the antenna element 14 is heated extremely severely, in the event of possible contact with the overhead line, while the short-circuit current which then flows and is in the kilo ampere range.

With the abovementioned dimensions and the comparatively small resonator structure 28 on the upper face of the base element 27, the antenna arrangement is designed for a comparatively narrow frequency range from about 5.15 - 5.875 GHz, as is required for some WLL (wireless local loop) and WLAN (wireless local area network) applications.

In contrast, the antenna arrangement 40 of the second exemplary embodiment illustrated in Figures 5 - 7 can be used for a considerably wider frequency range (870 to 2170 MHz). In this case as well, the antenna arrangement 40 as shown in Figure 5 has an electrically conductive base plate 48 (see also Figure 7) composed of a semi-hard aluminum alloy with a plate thickness of 15 mm, an antenna element 44 which acts as a monopole and is mounted on the base plate 48, a coaxial connecting socket 47 whose inner conductor 75 is connected at the feed point 42 to a connecting pin 43 on the antenna element 44, and a protective shroud 41. The lower edge of the shroud 41 is seated in an (elliptical) annular groove 58 in the base plate 48 and is attached to the base plate 48 by means of screws 50, which are screwed into the shroud 41 from underneath through attachment holes 59 in the base plate 48. The coaxial connecting socket 47 is in this case pushed

from above through a through-hole 63 in the base plate and makes contact from underneath with an attachment nut 45 which is screwed to an external thread on the connecting socket 47. A sealing ring 46 is once again
5 provided around the connecting socket 47 and is inserted into a corresponding annular groove 62 on the lower face of the base plate 48. The connecting socket 47 can in turn be protected by a removable protective cap 49. Outside the shroud 41, attachment holes 61
10 (Figure 7) are provided in the base plate 48, by means of which the antenna arrangement 40 can be attached to the outside of a vehicle.

The antenna element 44 (Figure 6) comprises a plate
15 composed of semi-hard aluminum alloy with a plate thickness of 10 mm (the plate thickness extends at right angles to the plane of the drawing in Figure 6). The antenna element 44 has a base element 54, which is like a bar, extends parallel to and at a distance from
20 the base plate 48, and has a height h_1 of 15 mm and a length of $(a_1+a_2+a_3+a_4+a_5) = 140$ mm. An attachment with the connecting pin 43 projecting downwards is provided at one end of the base element 54 (on the right in Figure 6), towards the base plate 48. The connecting
25 pin 43 is machined from solid in the example. However, it can just as well be in the form of a push-in pin once again. At the other end (on the left in Figure 6), a foot 52 with an attachment hole 53 is integrally formed, projecting downwards, on the base element 54.
30 The antenna element 44 can be mounted detachably on the base plate 48 by means of the foot 52 and a screw connection 51. A corresponding threaded hole 60 is provided in the base plate 48 for a screw to be screwed into (Figure 7).

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A plurality of resonant structures 55, ..., 57 are integrally formed on the base element 54 of the antenna element 44. The first resonant structure 55 corresponds

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to a step with a height h_2 of 15 mm after a distance a_1 of 30 mm. The second resonant structure 56 is a vertical bar with a height h_3 of about 50 mm and a width a_3 of 30 mm. The distance a_2 from the step is about 30 mm. The third resonant structure 57 is a short vertical bar with a width a_5 of 10 mm and a height h_4 of 9 mm. The dimensions of the resonant structures are by way of example. The location and configuration of the resonant structures 55, ..., 57 may be varied as required. Furthermore, further resonant structures may be provided between the two ends of the base element 54, or else beyond the screw connection 51.

The resonant structures may also be folded and their ends may be inclined or rounded. One example of an antenna element that has been modified in this way is illustrated in Figure 8. The antenna element 66 of the antenna arrangement shown in Figure 8 comprises a bar-like base element 70 which extends parallel to and at a distance from the base plate 65, and which is screwed to the base plate 65 at one end by means of a foot 69. A feed point 67 is once again located at the other end, at which the antenna element 66 is accessible via a coaxial connecting socket. A plurality of resonant structures 71, 72 and 73 are integrally formed on the base element 70. The resonant structures 71 and 72 are angled (folded); their corners are partially inclined and partially rounded. The corners of the resonant structure 73, which is in the form of a bar, are also rounded.

The antenna element 66 shown in Figure 8 has similar dimensions to those of the antenna element 44 shown in Figure 6 and allows the following frequency bands:

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|------------|-----------------|
| - GSM 900 | 870 - 960 MHz |
| - GSM 1800 | 1710 - 1880 MHz |
| - PCS 1900 | 1850 - 1990 MHz |

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- 1800/UMTS 1710 - 2170 MHz
WLL/WLAN 2.4 - 2.7 GHz; 3.4 - 3.7 GHz;
 5.15 - 5.875 GHz

5 to be covered. The resonant structure 71 influences the
low frequencies and the frequencies around 1 GHz. The
resonant structure 72 likewise influences the low
frequencies, but resonates mainly below 1 GHz. In this
case, the lower face of the base element 70 does not
10 run completely parallel to the base plate 65, but is
slightly stepped.

Figure 9 shows the calculated return loss of the
antenna arrangement 64 shown in Figure 8, plotted
15 against the frequency. As can be seen, the return loss
is less than 10 dB between approximately 800 MHz and
9 GHz.

LIST OF REFERENCE SYMBOLS

10, 40, 64	Antenna arrangement
11, 41	Shroud
12, 42, 67	Feed point
13, 43	Connecting pin
14, 44, 66	Antenna element (monopole)
15, 68	Screw
16, 46, 76	Sealing ring
17, 47	Connecting socket (coaxial)
18, 48, 65	Base plate
19, 49	Protective cap
20, 50	Screw
21	Socket
22, 52, 69	Foot
23	Through-hole
24	Blind hole
25	Connecting channel
26	Section (vertical)
27, 54, 70	Base element (like a bar)
28, 55, ..., 57	Resonant structure
29	Attachment
30	Threaded hole
31, 31'	Attachment flange
32	Mounting platform
33	Attachment hole
34	Threaded hole
35	Milled area
36, 37	Through-hole
38, 62	Annular groove (sealing ring)
39	Foot
45	Attachment nut
51	Screw connection
53	Attachment hole
58	Annular groove (shroud)
59	Attachment hole
60	Threaded hole
61	Attachment hole

63	Through-hole
71, 72, 73	Resonant structure
74, 75	Inner conductor (connecting socket)
a1, ..., a4	Distance
h1, ..., h4	Height

PATENT CLAIMS

1. A broadband antenna for transmitting and receiving the frequency range from about 800 MHz to about 9 GHz, comprising a monopole antenna element extending in a longitudinal direction substantially parallel to and at a distance above a planar, electrically conductive base plate between two opposite ends of said antenna element, said antenna element comprising at least one of aluminum and an aluminum alloy, wherein said antenna element is electrically conductively connected at a first end to said base plate, and said antenna element has a feed point at a second end thereof, which is electrically isolated from said base plate, wherein said antenna element is adapted to be connected to a radio-frequency device via said feed point.

2. The antenna as claimed in claim 1, characterized in that the antenna element is in the form of a solid metal plate, which preferably has a constant thickness transversely with respect to the longitudinal direction.

3. The antenna as claimed in one of claims 1 to 2, characterized in that the antenna element has a foot at the first end, and in that the antenna element is attached to the base plate by the foot.

4. The antenna arrangement as claimed in claim 3, characterized in that the foot has at least one threaded hole or attachment hole by means of which the foot is screwed to the base plate.

5. The antenna as claimed in one of claims 1 to 4, characterized in that a coaxial plug connector which is at right angles to the base plate and in particular is in the form of a connecting socket is arranged on the lower face of

the base plate in the area of the feed point, with its outer conductor being electrically conductively connected to the base plate and its inner conductor being electrically conductively connected through an opening in the base plate to the feed point of the antenna element.

6. The antenna arrangement as claimed in claim 5, characterized in that the connection between the feed point and the inner conductor of the coaxial plug connector is designed to be detachable.

7. The antenna as claimed in claim 6, characterized in that an electrically conductive connecting pin which projects downwards at right angles to the base plate is arranged at the feed point of the antenna element and fits in a socket which is fitted to the inner conductor of the coaxial plug connector.

8. The antenna as claimed in claim 7, characterized in that the connecting pin is integrally formed on the antenna element.

9. The antenna as claimed in claim 7, characterized in that the connecting pin is in the form of a push-in pin, and is pushed into a corresponding opening in the antenna element.

10. The antenna as claimed in one of claims 1 to 9, characterized in that the antenna element is covered on the outside by a removable shroud, which is detachably connected, in particular screwed, to the base plate.

11. The antenna as claimed in one of claims 1 to 10, characterized in that the antenna element has a bar-like

base element which runs in the longitudinal direction and to which additional resonant structures are fitted, distributed non-uniformly transversely with respect to the longitudinal direction.

12. The antenna as claimed in claim 11, characterized in that the resonant structures comprise elements which are integrally formed on the base element and are oriented at right angles to the base plate.

13. The antenna as claimed in claim 12, characterized in that the resonant structures are rectangular.

14. The antenna as claimed in claim 12, characterized in that the resonant structures are angled.

15. The antenna as claimed in claim 12 characterized in that the resonant structures have inclined corners.

16. The antenna as claimed in claim 12, characterized in that the resonant structures have rounded corners.