(54) Title: ANTENNA HAVING IMPROVED FRONT-TO-BACK RATIO

An antenna having improved front-to-back ratio, the antenna comprising a backplane (101), at least one driven antenna element (103) positioned on a forward side of the backplane, and first (102A) and second (102B) deflector plates disposed on opposing edges of the backplane, the first and second deflector plates extending rearwardly and outwardly from the opposing edges of the backplane (101). In another embodiment, an antenna having improved front-to-back ratio is disclosed in which the antenna comprises a first reflector backplane (101), at least one driven antenna element (108) positioned on a first side of the first reflector backplane, and a second reflector backplane (302) positioned on a second side of the first reflector backplane, wherein the second reflector backplane is fixed in substantially parallel relationship with respect to the first reflector backplane, and spaced away from the first reflector backplane.
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ANTENNA HAVING IMPROVED FRONT-TO-BACK RATIO

FIELD OF THE INVENTION

This invention relates generally to antennas and in particular to directional panel antennas suitable for cellular and other radiotelephone systems, and is more particularly directed toward a directional panel antenna having an improved front-to-back ratio.

BACKGROUND OF THE INVENTION

Low profile directional antenna systems, such as those composed of panel antennas, find many applications in cellular and other radiotelephone systems. A panel antenna, as is known in the art, is generally made up of one or more driven antenna elements mounted on one side of a reflector backplane. The backplane is usually a plate of conductive material, such as aluminum or brass.

In operation, a panel antenna is generally mounted so that the reflector backplane is perpendicular to the surface of the earth. The horizontal radiation pattern of a panel antenna can be varied through judicious design choices, so that horizontal beam widths in a range from about 45° to about 160° are generally available. Because panel antennas have a low profile, and the reflector backplane can serve as a mounting surface, panel antennas are often mounted to the sides of buildings in urban areas to help solve coverage problems. Of course, arrays of panel antennas can also be
mounted on conventional tower structures to yield nearly omnidirectional coverage patterns.

The major lobe of the horizontal radiation pattern is designed to extend forwardly from the radiating element of the antenna. The amount of electromagnetic radiation that extends rearwardly from the radiating element of the antenna (on the opposite side of the backplane), the backward lobe, is much less than that extending outward from the antenna element side of the backplane (the forward lobe). This front-to-back ratio of signal strengths, of course, is a desirable characteristic of a directional antenna system.

Although efforts have been made to improve the front-to-back ratio of antennas, there is still a need for an antenna with improved front-to-back ratio.

**SUMMARY OF THE INVENTION**

These needs and others are satisfied by the improved antenna of the present invention, in which an antenna having improved front-to-back ratio comprises a backplane, at least one driven antenna element positioned on a forward side of the backplane, and first and second deflector plates disposed on opposing edges of the backplane, the first and second deflector plates extending rearwardly and outwardly from the opposing edges of the backplane. The first and second deflector plates each include an extension portion that extends in a forward direction substantially perpendicular to the backplane. The backplane is oriented in a plane perpendicular to the earth's surface in normal operating position.

In one form of the invention, the driven antenna element may be a single antenna element or an array thereof. The element may comprise a dipole antenna or an array of dipole antennas may be used, such as a plurality of collinear dipole antennas. Each dipole antenna includes first and second dipole arms disposed substantially parallel to the backplane.
In one aspect of the invention, an antenna having improved front-to-back ratio is provided, the antenna comprising a backplane oriented in a plane perpendicular to the earth's surface in normal operating position, at least one dipole antenna positioned on a forward side of the backplane, the dipole antenna having first and second dipole arms disposed substantially parallel to the backplane, first and second deflector plates disposed on opposing edges of the backplane, the first and second deflector plates extending rearwardly and outwardly from the opposing edges of the backplane, and the first and second deflector plates each include an extension portion that extends in a forward direction substantially perpendicular to the backplane.

A method for improving front-to-back ratio of a directional panel antenna is also disclosed, the method comprising the steps of providing a backplane, providing at least one driven antenna element positioned on a forward side of the backplane, and providing first and second deflector plates disposed on opposing edges of the backplane, the first and second deflector plates extending rearwardly and outwardly from the opposing edges of the backplane, such that backward lobe amplitude decreases while forward lobe amplitude remains relatively constant, thereby improving the front-to-back ratio.

In another embodiment of the invention, an antenna having improved front-to-back ratio comprises a first reflector backplane, at least one driven antenna element positioned on a first side of the first reflector backplane, and a second reflector backplane positioned on a second side of the first reflector backplane, wherein the second reflector backplane is fixed in substantially parallel relationship with respect to the first reflector backplane, and spaced away from the first reflector backplane. The first reflector backplane is oriented in a plane perpendicular to the earth's surface in normal operating position.
In one form of this embodiment, the driven antenna element comprises at least one dipole antenna, and may comprise a plurality of collinear dipole antenna. Each of the dipole antennas includes first and second dipole arms disposed substantially parallel to the first reflector backplane.

The first reflector backplane has a first length, the second reflector backplane has a second length, and the second length is preferably greater than the first length by a factor of approximately fifty percent. The first reflector backplane has a top and a bottom, and the second reflector backplane extends beyond both the top and the bottom.

In another aspect, an antenna having improved front-to-back ratio comprises a first reflector backplane oriented in a plane perpendicular to the earth's surface in normal operating position, and having a top and a bottom. The antenna includes at least one radiating element positioned on a first side of the first reflector backplane. The radiating element may be a dipole antenna having first and second dipole arms disposed substantially parallel to the first reflector backplane, and a second reflector backplane positioned on a second side of the first reflector backplane, fixed in substantially parallel relationship with respect to the first reflector backplane, and having a length exceeding the length of the first reflector backplane by a factor of approximately fifty percent. The first reflector backplane has a top and a bottom and the second reflector backplane extends beyond both the top and the bottom.

A method is also disclosed for improving front-to-back ratio of a directional panel antenna in accordance with this second embodiment of the invention. The method comprises the steps of providing a first reflector backplane, providing at least one driven antenna element positioned on a first side of the first reflector backplane, providing a second reflector backplane positioned on a second side of the first reflector backplane, such that backward lobe amplitude decreases while forward lobe amplitude remains relatively constant.
Further objects, features, and advantages of the present invention will become apparent from the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front elevational view of an antenna in accordance with the present invention;
FIG. 2 is a side elevational view of the antenna of FIG. 1;
FIG. 3 is a top plan view of the antenna of FIG. 1.
FIG. 4 is a front elevational view of another antenna in accordance with the present invention;
FIG. 5 is a side elevational view of the antenna of FIG. 4;
FIG. 6 is a top plan view of the antenna of FIG. 4;
FIG. 7 is a front elevational view of an antenna in accordance with a second embodiment of the present invention;
FIG. 8 is a side elevational view of the antenna of FIG. 7;
FIG. 9 is a top plan view of the antenna of FIG. 7;
FIG. 10 is a front elevational view of another antenna in accordance with the second embodiment of the invention;
FIG. 11 is a side elevational view of the antenna of FIG. 10;
FIG. 12 is a top plan view of the antenna of FIG. 10;
FIG. 13 is a side elevational view of the antenna of FIGS. 10-12 in normal operating position, showing an associated radome in place;
FIG. 14 is a plot of the horizontal radiation pattern of a prior art antenna;
FIG. 15 is a plot of the horizontal radiation pattern of an antenna in accordance with the present invention; and
FIG. 16 is a plot of the horizontal radiation pattern of a further antenna in accordance with the present invention.
DETAILED DESCRIPTION OF THE INVENTION

In accordance with the present invention, an antenna having improved front-to-back ratio is described that provides distinct advantages when compared to antennas of the prior art.

FIGS. 1-3 depict an antenna 100 in accordance with the present invention. The antenna 100 comprises a backplane 101, formed of a conductive material, such as aluminum, which may be about 1/8 inch in thickness. The backplane 101 may be a flat plate, or may be formed with peripheral flanges that extend forwardly, so that a radome may be secured thereto, if desired, and as is common in the prior art. Stiffener plates 107 may be added to the backplane 101 to enhance structural integrity.

The backplane may also be made from a non-conductive material that has a conductive material deposited thereon, such as by painting, printing, vacuum deposition, or other techniques. In the alternative, a screen of conductive material, spaced appropriately, could be embedded in a non-conductive substrate to form a backplane. Further, other conductive backplanes, such as lattices, may be used.

A driven antenna element 103, or an array of elements, is positioned on a first side of the backplane 101. Arrays may be provided in a variety of well-known ways, and may include plural elements, such as plural dipoles. Depending upon the frequency range of interest, it is possible to construct antenna arrays by microstrip design techniques on printed circuit boards, on specialized substrates, or in other ways as well.

In the preferred form of the antenna 100, the driven antenna element 103 is a dipole antenna, having first and second opposed elements 104, 105 that are disposed substantially parallel to the backplane 101. These dipole elements 104, 105 are also formed from a conductive material,
preferably brass, and are supported on a metal post 108. A plurality of dipole antennas 103 may be used.

From a suitable connector 111 mounted to the backplane 101, a coaxial feed line runs to the antenna element 103, and a matching stub 110 of coaxial line is provided for tuning purposes in a fashion well-understood in the antenna art. An adjustment ring 106, formed of an insulating material, such as plastic, is provided to adjust lateral spacing of the opposing dipole elements 104, 105, also for tuning purposes.

First and second deflector plates 102A, 102B are provided adjacent the backplane. Each of the deflector plates 102A, 102B is preferably formed from a conductive material, such as aluminum, and is secured to a mounting bracket 113 by bolts 114. Of course, the deflector plates 102A, 102B could also be manufactured from a conductive screen or lattice, or in other ways described above respecting the backplane 101, in order to minimize wind loading as well as material cost.

Each of the deflector plates 102A, 102B includes a forward extension 112A, 112B, that is substantially perpendicular to the backplane 101 and extends outward from the backplane surface for a distance of about 1/2 to about 3/4 inch. Preferably, the forward extension portions 112A, 112B are integrally formed with the deflector plates 102A, 102B, although the forward extensions could also be separate elements that are separately secured to the backplane 101.

The deflector plates 102A, 102B are secured to the backplane 101 in such a way that electrical conductivity is maintained between the deflector plates 102A, 102B and the backplane 101. In operation, the deflector plates 102A, 102B extend rearwardly and outwardly of the backplane 101, making an angle of about 135° with respect to the antenna mounting surface of the backplane.

The deflector plates 102A, 102B are effective in reducing backlobe amplitude of the radiation pattern of the antenna 100. It has been determined that the backlobe reducing properties of the rearwardly extending deflector plates 102A,
102B has a secondary effect of increasing the horizontal beam width in the forward direction. The forward extensions 112A, 112B act to reduce the beam width increase attributable to the effect of the deflector plates 102A, 102B.

Turning now to FIGS. 4-6, another antenna 200 in accordance with the present invention is depicted. The antenna 200 is virtually identical to the antenna 100 described above, with the exception that the antenna 200 includes multiple driven antenna elements 203 and the backplane 201 is physically longer (about 2 feet long by one foot wide as opposed to 1 foot by 1 foot for antenna 100). Consequently, components in FIGS. 4-6 have been given reference symbols differing from those of like components in FIGS. 1-3 only in the hundreds place, and the component parts of the antenna of FIGS. 4-6 will not otherwise be discussed in detail here for the sake of brevity.

As mentioned briefly above, the antenna 200 includes two driven antenna elements 203, both of which are dipole antennas similar in construction to the dipole 103 discussed previously. Since the antennas 203 are aligned along their opposing arms 204, 205, the antennas 203 are collinear dipole antennas.

FIGS. 7-9 depict a second embodiment of an antenna 300 that has an improved front-to-back ratio in accordance with the present invention. Many of the components of the antenna 300 are identical to those discussed with reference to FIGS. 1-3, and have been given the same reference symbols as in FIGS. 1-3. Consequently, discussion of these common components will be limited. Just as in the previous embodiments, a driven antenna element 103 is disposed on a first side of a first reflector backplane 101.

A second reflector backplane 302 is positioned on a second side of the first reflector backplane 101. Spacers 312 maintain the second reflector backplane 302 in a substantially parallel relationship with respect to the first reflector backplane 101, and the spacers are secured by bolts 313.
The length 314 of the first reflector backplane 101 is about 1 foot in the preferred embodiment. The second reflector backplane 302 has a vertical length 315 of about 2 feet. Thus, the length 315 of the second reflector backplane 302 exceeds the length 314 of the first reflector backplane 101 by at least about 50 percent.

FIGS. 10-12 illustrate a similar additional embodiment of an antenna 400 having improved front-to-back ratio in accordance with the present invention. With the exception of the second reflector backplane 402, and the absence of deflector plates, the embodiment illustrated in FIGS. 10-12 is virtually identical to the embodiment described with reference to FIGS. 4-6, and identical reference symbols have consequently been employed where applicable. The antenna 400 has a plurality of driven antenna elements 203, arranged as collinear dipole antennas.

FIG. 13 illustrates the antenna 400 in normal operating position, with the first reflector backplane 201 oriented in a plane perpendicular to the earth's surface. A radome 501, preferably formed from a plastic material, such as ABS, is affixed to the antenna 400. Dashed lines are associated with the top 502 and bottom 503 of the antenna 400. The second reflector backplane 402 extends beyond both the top 502 and the bottom 503 of the antenna 400. Of course, any of the antenna described above could be equipped with similar radomes for protection of the antenna components against the elements.

FIG. 14 is a plot of the horizontal radiation pattern of a prior art panel antenna without the improvements of the present invention. The forward lobe 601 extends outwardly to the limits of the plot, and the backward lobe 602 has a relative amplitude about 20 dB (decibels) below that of the forward lobe 601.

FIG. 15 is a plot of the horizontal radiation pattern of the panel antenna 200 of FIGS. 4-6 of the present invention, which includes the deflector panels 202A, 202B with forward extensions 212A, 212B. As can be discerned from an
examination of FIG. 15, the amplitude of the forward lobe 701 has remained relatively constant as compared to the lobe of FIG. 14, while the amplitude of the backward lobe 702 has become virtually nonexistent in the direction opposite the maximum forward lobe amplitude 701. Front-to-back ratio has improved considerably in this implementation.

In addition, the forward extensions 212A, 212B offer additional control over the horizontal beamwidth of the antenna 200, and allow compensation for any changes in aperture introduced by the installation of the deflector plates 202A, 202B.

FIG. 16 is a plot of the horizontal radiation pattern of the antenna 400 employing a second reflector backplane 402. As will be appreciated from the plot of FIG. 16, the amplitude of the backlobe 802 has been decreased by about 5 dB when compared to the unaltered panel antenna plot of FIG. 14. Since front-to-back ratio of the antenna 400 is the ratio of forward lobe amplitude to backward lobe amplitude, introduction of the second reflector backplane 402 results in a desirable improvement (an increase) in antenna front-to-back ratio.

There has been described herein an antenna having improved front-to-back ratio and which is improved over the prior art. It will be apparent to those skilled in the art that modifications may be made without departing from the spirit and scope of the invention. Accordingly, it is not intended that the invention be limited except as may be necessary in view of the appended claims.

What is claimed is:
CLAIMS

1. An antenna having improved front-to-back ratio, the antenna comprising:
   a backplane;
   at least one driven antenna element positioned on a forward side of said backplane; and
   first and second deflector plates disposed on opposing edges of said backplane, said first and second deflector plates extending rearwardly and outwardly from said opposing edges of said backplane.

2. The antenna of claim 1, wherein said first and second deflector plates each include an extension portion that extends in a forward direction substantially perpendicular to said backplane.

3. The antenna of claim 1, wherein said backplane is oriented in a plane perpendicular to the earth's surface in normal operating position.

4. The antenna of claim 1, wherein said at least one driven antenna element comprises at least one dipole antenna.

5. The antenna of claim 4, wherein said at least one dipole antenna comprises a plurality of collinear dipole antennas.

6. The antenna of claim 4, wherein said dipole antenna includes first and second dipole arms disposed substantially parallel to said backplane.

7. An antenna having improved front-to-back ratio, the antenna comprising:
   a backplane oriented in a plane perpendicular to the earth's surface in normal operating position;
at least one dipole antenna positioned on a forward side of said backplane, the dipole antenna having first and second dipole arms disposed substantially parallel to said backplane; first and second deflector plates disposed on opposing edges of said backplane, said first and second deflector plates extending rearwardly and outwardly from said opposing edges of said backplane; and said first and second deflector plates each include an extension portion that extends in a forward direction substantially perpendicular to said backplane.

8. For a directional panel antenna having a forward lobe and a backward lobe, a method for improving front-to-back ratio, the method comprising the steps of:
(a) providing a backplane;
(b) providing at least one driven antenna element positioned on a forward side of the backplane; and
(c) providing first and second deflector plates disposed on opposing edges of said backplane, said first and second deflector plates extending rearwardly and outwardly from said opposing edges of said backplane, such that backward lobe amplitude decreases while forward lobe amplitude remains relatively constant.

9. An antenna having improved front-to-back ratio, the antenna comprising:
a first reflector backplane;
at least one driven antenna element positioned on a first side of the first reflector backplane; and
a second reflector backplane positioned on a second side of the first reflector backplane;
wherein said second reflector backplane is fixed in substantially parallel relationship with respect to said first reflector backplane, and spaced away from said first reflector backplane.
10. The antenna of claim 9, wherein the first reflector backplane is oriented in a plane perpendicular to the earth's surface in normal operating position.

11. The antenna of claim 9, wherein said at least one driven antenna element comprises at least one dipole antenna.

12. The antenna of claim 11, wherein said at least one dipole antenna comprises a plurality of collinear dipole antenna.

13. The antenna of claim 11, wherein said dipole antenna includes first and second dipole arms disposed substantially parallel to said first reflector backplane.

14. The antenna of claim 9, wherein said first reflector backplane has a top and a bottom, and said second reflector backplane extends beyond both said top and said bottom.

15. The antenna of claim 14, wherein said first reflector backplane has a first length, said second reflector backplane has a second length, and said second length exceeds said first length by at least fifty percent.

16. An antenna having improved front-to-back ratio, the antenna comprising:
   a first reflector backplane oriented in a plane perpendicular to the earth's surface in normal operating position, and having a top and a bottom;
   at least one dipole antenna positioned on a first side of the first reflector backplane, the dipole antenna having first and second dipole arms disposed substantially parallel to said first reflector backplane; and
   a second reflector backplane positioned on a second side of the first reflector backplane, fixed in substantially parallel relationship with respect to said first reflector
backplane, and having a length exceeding the length of said first reflector backplane by at least about fifty percent, and wherein said first reflector backplane has a top and a bottom and said second reflector backplane extends beyond both said top and said bottom.

17. For a directional panel antenna having a forward lobe and a backward lobe, a method for improving front-to-back ratio, the method comprising the steps of:

(a) providing a first reflector backplane;

(b) providing at least one driven antenna element positioned on a first side of the first reflector backplane; and

(c) providing a second reflector backplane spaced away from and positioned on a second side of the first reflector backplane, such that backward lobe amplitude decreases while forward lobe amplitude remains relatively constant.
FIG. 14
PRIOR ART
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) : H01Q 21/12
US CL. : 343/797, 801, 805, 806, 810, 811, 812, 813, 815, 817, 818, 823
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
U.S. : 343/797, 801, 805, 806, 810, 811, 812, 813, 815, 817, 818, 823

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
none

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
none

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US 5,589,843 A (MEREDITH ET AL.) 31 DECEMBER 1996, ENTIRE DOCUMENT</td>
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<td>US 5,229,783 A (TILSTON ET AL.) 20 JULY 1993, ENTIRE DOCUMENT</td>
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<td>US 5,589,843 A (MEREDITH ET AL.) 31 DECEMBER 1996, ENTIRE DOCUMENT</td>
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<td>US 5,111,214 A (KUMPFBECX ET AL.) 05 MAY 1992, ENTIRE DOCUMENT</td>
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Further documents are listed in the continuation of Box C.

Date of the actual completion of the international search
14 MAY 1997

Date of mailing of the international search report
09 JUN 1997

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