A dual band antenna with dual antenna elements, each including a first and a second antenna element (5b, 6b), for transmitting and/or receiving radio frequency radiation in a first, relatively low frequency band and a second, relatively high frequency band, respectively, and an electrically conductive, substantially planar reflector device (1). Each first antenna element (5b) is located close to an associated one (6b) of the second antenna elements on a front side of the reflector device so as to define first and second radiation beams. The reflector device, on each lateral side thereof, is provided with an edge portion formed as a groove (11, 12), which is open towards the front side of the reflector device and which is dimensioned so as to widen the azimuth beam width of the second beam to an angular value being close to that of the first beam, whereby both beams will have substantially the same azimuth width.
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DUAL BAND ANTENNA

The present invention relates to a dual band antenna, comprising at least one first antenna element and an associated second antenna element for transmitting and/or receiving radio frequency radiation in a first, relatively low frequency band and a second, relatively high frequency band, respectively, and an electrically conductive, substantially planar reflector device, said at least one first antenna element being located close to said associated second antenna element so as to form at least one combined antenna element on a front side of said reflector device and to define first and second radiation beams, respectively, each having a specific azimuth beam width being substantially symmetrical with respect to a central, longitudinal plane oriented perpendicularly to said planar reflector device and extending through said at least one combined antenna element.

Recently, the demand for antennas for mobile wireless applications has increased dramatically, and there are now a number of land and satellite based systems for wireless communications using a wide range of frequency bands. Accordingly, there is also a need for antennas being operable in two or more frequency bands, preferably also with dual polarization in order to accomplish a desired diversity of the radio frequency radiation received by the antenna. Such dual band, dual polarized antennas are especially useful in base station antennas.

Due to the capacity problems encountered in the existing AMPS-800 and GSM-900 MHz systems, many operators have recently acquired licenses for the DCS-1800 or PCS-1900 MHz band as well, i.e. a much higher frequency band which is widely separated from the lower frequency band by approximately an octave. Therefore, in order to make use of the existing sites for the new frequency bands, a favourable way of implementing the new systems is to replace the existing GSM or AMPS
antennas by dual band antennas operable, e.g., in the dual bands GSM/DCS or AMPS/PCS.

A dual band antenna of the kind mentioned in the first paragraph is disclosed in the Swedish patent application 9704642-9 (Allgon AB), wherein each dual or combined antenna element comprises aperture coupled, planar, mutually parallel patches being placed one on top of the other and being centered in relation to a central point of a cross-shaped aperture in a ground plane layer serving as a reflector device. Microwave power is fed from a feed network in two separate frequency bands, the microwave power in a first frequency band being fed via the aperture in the reflector device to a first radiating patch, and the microwave power in a second frequency band (the higher band) being fed via the aperture in the reflector device and via a coupling patch and a likewise cross-shaped aperture in the first radiating patch to a second radiating patch, which is smaller and operates in the higher frequency band.

Such an antenna structure with combined antenna elements has turned out to be very advantageous in production and use. However, a practical problem has arisen with regard to the width of the radiating beams on the front side of the antenna. Because of the different wavelengths, e.g., 0.326m and 0.167m, respectively, the width of each beam in azimuth, measured as the half power limit (-3dB), will be quite different from one another, the beam in the lower frequency band being much wider than the beam in the higher frequency band.

Accordingly, a main object of the present invention is to provide a dual band antenna structure which enables a modification of the beam width in the higher frequency band, in particular so as to become close to the beam width in the lower frequency band.
Other secondary objects are to provide an antenna structure which is easy to implement in serial production and which is well suited for practical use in base stations operating in at least two frequency bands, including bands having centre frequencies in the regions 800-950 MHz and 1750-1950 MHz. Still another object is to achieve a more favourable front to back ratio of the radiated power.

The main object stated above is achieved, according to the present invention, in that the reflector device, on each lateral side thereof, is provided with an edge portion formed as a groove, which is open towards the front side of the reflector device and which is dimensioned so as to widen the beam width of said second beam (in the higher frequency band), in particular to an angular value being close to that of said first beam (in the lower frequency band). The widening of the beam in the higher frequency band is caused by a secondary radiation, with a horizontal electrical field component, from the edge portions of the reflector device.

The exact configuration and dimensions of the grooves are of course dependent i.a. on the particular frequency bands being used, the configuration of the combined antenna elements, the configuration of the reflector device, and the geometry and material of the cover or radome normally mounted as a protective cover on the front side of the antenna.

As a general rule, however, tests have shown that the depth of the groove should be 0.1 to 0.3 times the wavelength of the radiation of said second frequency band (the higher frequency band) and the width of the groove should be about 0.2 times the above-mentioned wavelength. Normally, the groove has such dimensions that it has only a minor effect on the width and other properties of the beam in the first frequency band (the lower frequency band). A typical lateral width of the whole reflector device is 0.2 to 0.3 m, in particular about 0.25 m-0.28 m for an antenna with a 70° azimuth beam width (or about
1.5 times the wavelength in the higher frequency band) and the width of each longitudinal groove at the edges of the reflector is about 0.033 m (or about 0.2 times the wavelength in the higher frequency band).

The geometrical configuration of the grooves can be selected as desired by those skilled in the art, e.g., with a rectangular, arcuate or V-formed cross-section. For practical reasons, the groove is preferably defined by longitudinally extending, substantially planar wall portions, such as two side wall portions and an intermediate bottom wall portion, obtained by bending of a metallic sheet material, such as aluminium, preferably in one piece with the rest of the reflector device.

In a particular embodiment, which has been tested and proven to give excellent performance, the central portion of the reflector device, between the edge portions being formed as grooves, is limited laterally or sideways by lateral, up-standing wall portions and longitudinally along a linear array of seven dual antenna elements (stacked patches) by metallic (aluminium) shield wall elements extending transversely in the region between each pair of adjacent dual elements in the linear array. The total length of this antenna, including the frontal radome, is 1.2m, the total width thereof being 0.3m and the depth or thickness thereof being 0.11m.

The invention will now be explained further with reference to the appended drawings illustrating the above-mentioned preferred embodiment of the dual band antenna.

Fig. 1 shows schematically, in a perspective, exploded view, the most essential parts of the antenna (two feed cables and a protective front cover or radome being left out for clarity);
Fig. 2 shows, likewise in an exploded view, a transverse cross-section of the antenna shown in fig. 1, at the second antenna element.

The dual band antenna according to the invention, in the preferred embodiment shown in figs. 1 and 2, consists essentially of a ground plane layer serving as a reflector device 1, a feed network (not shown specifically) formed on the lower side of a substrate layer 2, electrically conducting shield cages 3a, 3b, etc. serving to prevent microwave propagation backwards (downwards in figs. 1 and 2), and coupling and radiating patches 4a, 5a, 6a; 4b, 5b, 6b; etc. constituting dual or combined antenna elements 7a, 7b, etc. being mounted in a linear array along the longitudinal axis of the elongated antenna.

Each combined antenna element, e.g. the element 7b visible in fig. 2, is of the general kind described in the above-mentioned Swedish patent application 9704642-9, i.e. comprising two planar, mutually parallel radiating patches 5b, 6b being fed with microwave power from the feed network on the substrate 2 via a cross-shaped aperture (not visible in fig. 1) in the ground plane layer or reflector 1, there being one part of the network and an associated feed cable feeding power in one linear polarization (slanted +45°) and another part of the network and an associated feed cable feeding power in an orthogonal polarization (slanted -45°). The microwave power is supplied in two separate frequency bands, namely a lower band 880-960 MHz (GSM) and an upper band 1710-1880 MHz (DCS), the power in the lower band being fed to the somewhat larger patch 5b, from which it is radiated generally upwards (in the drawing figures) in a well-defined beam, and the power in the upper band being fed to the smaller patch 6b, from which it is radiated generally upwards, likewise in a well-defined beam.

The microwave power in the upper band, which is to be radiated from the patch 6b, is transferred from the feed network via a
cross-shaped aperture 9b (fig.1) in the radiating patch 5b, as explained in the above-mentioned Swedish patent application 9704642-9, the disclosure thereof being included herein by reference. The intermediate, relatively small patch 4b, having approximately the same dimensions as the relatively small radiating patch 6b, serves as a coupling member which is necessary for the transfer of microwave power from the feed network to the radiating patch 6b.

The substrate layer 2 is made of a teflon material, e.g., of the kind denoted DICHAD 527, and the patches located on top of each other are separated by spacing elements (not shown) or, alternatively, a foam material (not shown), e.g., of the kind denoted ROHACELL.

Dual polarization and accompanying diversity is achieved in each band by way of orthogonal linear polarization obtained by excitation of the respective, mutually perpendicular slots in each aperture (not shown) in the reflector device, the slots being slanted 45° in opposite directions relative to the central longitudinal axis of the antenna. The linear polarization, which is perpendicular to the respective slot, will also be oriented cross-wise with a corresponding slant of 45°.

The spacing between the smaller radiating patches 6a, 6b, etc., operating in the upper band, is approximately one wavelength, i.e. about 0.17 m, and the spacing between the larger radiating patches 5a, 5b, etc. is of course the same in absolute length units (but smaller in terms of wavelengths), since the patches in each combined antenna element are centered in relation to each other and in relation to the centre of the associated cross-shaped aperture.

Measurements have shown that the input return loss, the isolation between the dual polarized channels and the two frequency bands as well as the radiation properties and gain all have
very good values. Specifically, it has turned out that the cross-polarization level in the slant 45° antenna has been substantially reduced due to the fact that the horizontal and vertical field components both have approximately the same beam width. Also, the front to back ratio of the radiated power has been improved, especially in the upper band. The inter-channel isolation (each channel corresponding to a certain polarization) has been improved, primarily by means of metallic shield wall elements B (fig. 1) mounted transversely in the region between each pair of adjacent dual antenna elements.

The inter-channel isolation has also been advantageously affected by making the radiating patches slightly rectangular, i.e. not exactly square, with one side edge about 1 to 5% longer than the other side edge.

Moreover, in accordance with the present invention, the width of the beams radiated from the antenna towards the front side thereof (upwards in the drawing figures) is virtually the same in the two separate frequency bands. Thus, in both bands, the beam width is 72° in azimuth, or 36° symmetrically on both sides from a central, longitudinal plane being perpendicular to the plane of the reflector 1 through the central points of the various patches and the cross-shaped apertures.

The coinciding beam widths have been achieved by a specific configuration of the reflector device 1 at the longitudinal edge portions thereof, viz. in the form of longitudinally extending grooves 11, 12 on each lateral side of the reflector device 1. These grooves 11, 12 are open or face towards the front side of the antenna (upwards in the drawing figures) and are defined by substantially planar wall portions, viz. side wall portions 11a, 11b; 12a, 12b and an intermediate bottom wall portion 11c; 12c, formed by bending the metal sheet material of the reflector 1, which is thus formed in one integral piece.
The central portion 10 of the reflector device 1 is planar and carries the patches (4b, 5b, 6b in fig.2) on the front side and the substrate layer and the shield cages (2 and 3b in fig. 2) on the back side. The central, planar portion 10 merges with upwardly projecting, outwardly slightly inclined wall portions 13, 14 and horizontal wall portions 15, 16, which in turn merge with the wall portions 11a, 12a defining the inner wall of the respective groove.

The dimensions of the grooves are in accordance with the specifications indicated in the first, general part of the description, the width of each groove being 33.5 mm and the depth thereof being 22 mm. With such dimensions, it has turned out that the beam width in the upper band, having a centre frequency wavelength of 167 mm, is substantially enlarged so as to coincide with that of the lower band, having a centre frequency wavelength of 326 mm. The beam width of the lower band is not very much affected by the relatively small irregularities of the grooves 11, 12 but is rather determined by the total width of the reflector device, this total width being 265 mm in the illustrated example. As appears from fig. 2, the bottom wall portions 11c, 12c of the grooves are slightly elevated in relation to the central portion 10 of the reflector device 1.

The dual band antenna according to the invention can be modified considerably within the scope of the appended claims. Thus, the particular shape and dimensions of the grooves 11, 12 can be varied. The grooves may alternatively be designed as separate metal elements mounted on each lateral side of the reflector device.

The radiating patches 5b, 6b can be replaced by other kinds of dual or combined antenna elements, such as dipole structures. Moreover, the antenna can be provided with only one combined antenna element instead of a linear array.
The central portion 10 of the reflector device may be formed of a synthetic material, e.g., teflon, coated with an electrically conductive material.

Finally, circular polarization may be used instead of cross polarization provided that the two feed channels are combined by a quadrature hybrid wide band branch-line coupler.
CLAIMS

5  1. A dual band antenna, comprising
   - at least one first antenna element (5b) and an
     associated second (6b) antenna element for trans-
     mitting and/or receiving radio frequency radiation in
     a first, relatively low frequency band and a second,
     relatively high frequency band, respectively, and
   - an electrically conductive, substantially planar
     reflector device (1),
   - said at least one first antenna element (5b) being
     located close to said associated second antenna
     element (6b) so as to form at least one combined
     antenna element (7b) on a front side of said reflector
     device and to define first and second radiation beams,
     respectively, each having a specific azimuth beam
     width being substantially symmetrical with respect to
     a central, longitudinal plane oriented perpendicularly
     to said planar reflector device and extending through
     said at least one combined antenna element (7b),
     characterized in that
     - said reflector device (1), on each lateral side of
       said central, longitudinal plane, is provided with an
       edge portion formed as a groove (11, 12), which is
       open towards said front side of said reflector device,
     - said groove being dimensioned so as to widen the
       azimuth beam width of said second beam.

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2. An antenna as defined in claim 1, wherein the azimuth
   beam width of said second beam is widened to an angular value
   being close to that of said first beam, whereby both beams
   will have substantially the same azimuth beam width.

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3. An antenna as defined in claim 1, wherein said at least one combined antenna element (7b) comprises at least two patch elements (5b, 6b).

5 4. An antenna as defined in claim 3, wherein said patch elements (5b, 6b) are stacked one on top of the other in each combined antenna element (7b).

5. An antenna as defined in claim 1, wherein said at least one combined antenna element (7a, 7b, etc.) comprise at least two elements arranged in a linear array along said central, longitudinal plane.

6. An antenna as defined in claim 5, wherein metallic shield wall elements (8) extend transversely in a region between adjacent combined antenna elements in said linear array.

7. An antenna as defined in claim 1, wherein said groove at each edge portion is defined by longitudinally extending, substantially planar wall portions (11a, 11b, 11c; 12a, 12b, 12c).

8. An antenna as defined in claim 7, wherein said wall portions comprise two side wall portions (11a, 11b; 12a, 12b) and a bottom wall portion (11c, 12c).

9. An antenna as defined in claim 1, wherein
   - the depth of said groove (11, 12) is 0.1 to 0.3 times the wavelength of the radiation in said second, relatively high frequency band and
   - the width of said groove (11, 12) is about 0.2 times the wavelength of the radiation in said second, relatively high frequency band.

10. An antenna as defined in claim 1, wherein
a centre frequency of said first frequency band is in the region 800-950 MHz and a centre frequency of said second frequency band is in the region 1750-1950 MHz, and

the total width of said reflector device, including said grooves at the longitudinal edges thereof, is 0.2 to 0.3 mm.
# International Search Report

**A. Classification of Subject Matter**

**IPC6:** H01Q 19/185, H01Q 21/00  
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)

**IPC6:** H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

**SE,DK,FI,NO classes as above**

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. Documents Considered to be Relevant**

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- Further documents are listed in the continuation of Box C.  
- See patent family annex.

* Special categories of cited documents
  - "A" document defining the general state of the art which is not considered to be of particular relevance
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**Date of the actual completion of the international search:** 10 Sept. 1999  
**Date of mailing of the international search report:** 18-10-1999

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