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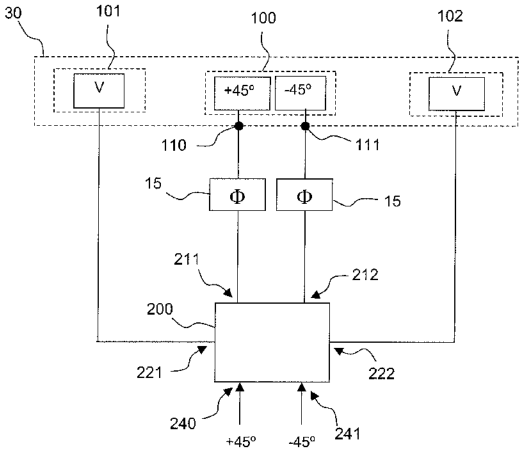

(57) Abstract: The present invention concerns a dual-polar antenna for a base station of mobile radio systems with adjustable azimuth beamwidth comprising at least a set of radiating elements (30) including an inner group of radiating elements (100) and two outer groups of radiating elements (101, 102) and the set of radiating elements (30) comprising at least a power division network (200) connected to each group of radiating elements (100, 101, 102), the inner group of radiating elements (100) being configured to radiate or receive two nominally orthogonally polarized signals and the outer groups of radiating elements (101, 102) being configured to radiate or receive signals with a single polarization. According to the invention, the set of radiating elements (30) comprises a single power division network (200) feeding the inner (100) and outer (101, 102) groups of radiating elements, the single power division network (200) comprising two inputs (240, 241), one for each of the input polarized signals. This dual-polar antenna has a chosen value of azimuth beamwidth using a simpler and less costly arrangement of radiating elements and feed networks.

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A DUAL-POLAR ANTENNA FOR A BASE STATION OF MOBILE RADIO SYSTEMS WITH ADJUSTABLE AZIMUTH BEAMWIDTH

The invention concerns a dual-polar antenna for base station of mobile radio systems with adjustable azimuth beamwidth.

Base stations are typically equipped with several transmit-receive antennas which cover sectors of terrain surrounding the base station. An important consideration in determining the necessary capacity of a base station is the number and angular width of these sectors. It is common for each base station to be equipped with multiple antennas connected to radio transmitters and receivers, each antenna having an azimuth half-power (3dB) beamwidth of between 65 degrees and 90 degrees.

Many mobile radio system operators provide services which use multiple interface standards and frequency bands, for example using the GSM protocol in the frequency bands 1710 – 1880MHz and the W-CDMA protocol in the band 1900 – 2170MHz. To reduce the cost and physical size of the antenna systems required at each base station it is common for these different radio systems to be served by common antennas. These antennas are required to provide essentially constant operational parameters over the whole frequency band 1710 – 2170MHz, a fractional bandwidth of 26%.

The capacity of a base station can be less than the theoretical maximum if regularly arranged sectors of coverage are used in locations in which the distribution of users is non-uniform, or in non-uniform land.

In a system using a code-division multiple access (CDMA) protocol, such as CDMA-2000 or W-CDMA, users whose location lies in the overlap area between adjacent sectors communicate through the radio equipment of all the sectors within whose coverage they lie. While this arrangement provides highly reliable service it also results in a single user consuming radio resources in more than one sector, which can relate to the same or different base stations.

In these circumstances it is advantageous to be able to remotely adjust the angular width of the sectors of coverage, a parameter primarily determined by the azimuth beamwidth of the antennas serving the appropriate sectors.

Mobile radio base stations are often equipped with antennas providing for the transmission and reception of two separate radio signals, each signal being linearly polarized and having planes of polarization inclined nominally ± 45 degrees relative to the vertical plane. Such signals are polarized mutually at right angles and their use facilitates the achievement of polarization diversity (“Polarization diversity antennas for compact base stations », Microwave Journal, January 2000, Volume 43, No 1, pp 76 - 88).

The transmission or reception of signals with the described polarization requires the use of antenna radiating elements capable of transmitting and receiving signals with these polarizations.

An antenna array such as described in the cited article would typically be expected to comprise an alignment of identical radiating elements.

Figures 1 and 2 of the present application are representative of antennas.

Figure 1 shows configuration of a base station antenna, in which a single vertical column comprising between 4 and 16 radiating elements 1 in the vertical plane is mounted in front of a conductive surface 2 which acts as a reflector, creating a unidirectional beam in the direction of the arrow 3 typically in or close to the horizontal plane.

Figure 2 shows a configuration of a base station antenna comprising multiple vertical columns of radiating elements.

Each of the radiating elements 1 comprises a crossed dipole, patch or other configuration chosen to provide the required characteristics of azimuth beamwidth, impedance match and polarization.

It is well known that the azimuth beamwidth of simple radiating elements including patches and crossed-dipoles can be modified by the use of a suitably shaped reflecting screen behind the elements, the shaping of the edges of the screen, the provision of slots in the edges of the screen, or by the use of slots in additional suitably placed passive parasitic elements. Such parasitic elements radiate by virtue of currents induced in them by the fields created by the nearby actively excited elements of the antenna.

The extent of control of the radiation pattern by the use of parasitic elements is limited by the frequency bandwidth over which the antenna is required to operate. As the frequency changes the amplitude and phases of the currents in the parasitic elements, the radiation pattern of the driven element combined with its associated parasitic elements changes in consequence.

The provision of a stable azimuth half-power (3dB) beamwidth wider than about 70 degrees (for example 90 degrees) has been found to be not easily achieved without the use of more complex and expensive configurations of radiating elements.

A wide, stable and adjustable azimuth beamwidth can be obtained by the use of a plurality of radiating elements in which the relative amplitudes of the signals fed to each element are fixed at a suitable value and the relative phases of the signals are varied. The phase of each radiating element can be adjusted independently.

In the form previously described, an antenna suitable for use at a mobile radio base station would comprise an array of n radiating elements wide in the horizontal plane (where n has a typical value of 3) and m radiating elements in the vertical plane where m has a value chosen according to the total gain required from the antenna, typically between 4 and 16 radiating elements, as shown in figure 2.

Each group of n radiating elements 1 disposed in the horizontal plane is typically identical in configuration. In the case of antennas designed to radiate and receive dual-polarized signals each radiating element 1 is typically designed to support radiating currents having each of the radiated polarizations. In such an array a full feed network with n x m branches is necessary for each of the two radiated polarizations.

This configuration provides a complex antenna array of identical dual-polar radiating elements together with separate power division networks and phase shifters associated with each polarization.

It is the objective of the present invention to permit the achievement of a dual-polar antenna having a chosen value of azimuth beamwidth using a simpler and less costly arrangement of radiating elements and feed networks.

To this end, the invention concerns a dual-polar antenna for base station of mobile radio systems with adjustable azimuth beamwidth comprising:

- at least a set of radiating elements comprising :
  - an inner group of radiating elements having at least two input ports,
  - two outer groups of radiating elements, and

- at least one power division network connected to each group of radiating elements,
- the inner group of radiating elements is comprised of radiating elements capable of radiating and/or receiving two nominally orthogonally polarized signals,
- the outer groups of radiating elements are comprised of radiating elements capable of radiating and/or receiving signals with a single polarization.

According to the invention:

- the set of radiating elements comprises a single power division network feeding the inner and outer groups of radiating elements, said single power division network comprising two inputs, one for each of the input polarized signals.

According to various embodiments, the present invention also concerns the characteristics below, considered individually or in all their technical possible combinations:

- the inner group of radiating elements comprises a single dual polar radiating element,

- the dual polar radiating elements are crossed-dipole radiating elements,

- the dual polar radiating elements are patch radiating elements,

- the outer groups of radiating elements comprise each a single radiating element,

- the single power division network of the set of radiating elements comprises:
    - o two outputs connected to the two input ports of the inner group of radiating elements respectively,
    - o two outputs, each connected to one of the outer groups of radiating elements,

- it further comprises two variable phase shifters, each variable phase shifter being connected to one of the two input ports of the inner group of radiating elements and to one of the two outputs of the power division network,

- the power division network is a coupling network comprising :
    - o two transmission lines, each of the transmission lines being connected between one of the input ports of the inner group of

radiating elements and one of the input ports of the coupling network, respectively,

- a coupling line having a portion inductively coupled to a portion of each of the transmission lines of the coupling network, said coupling line comprising on one side, a first unconnected end and on the other side, a second end connected to two output lines thereby forming a Tee-junction, each output line being connected to one of the outer radiating elements, respectively,

- the coupling network comprises a single variable phase shifter within the coupling line and connected to an input end of the inductively coupled portion of the coupling line and the Tee junction,

- it comprises m sets of radiating elements aligned in the vertical plane, forming an antenna array,

- each variable phase shifter comprises a control device, the control device of each of the variable phase shifters being connected to a bus linked to a central unit, whereby signals corresponding to a selected azimuth beamwidth are transmitted to each variable phase shifter from the central unit,

- the central unit is linked to a data communication means so that the beamwidth can be remotely controlled.

The description of the invention is illustrated by the following drawings in which:

- Figure 1 represents a configuration of a typical base station antenna, according to prior art, comprising a single vertical column of radiating elements ;
- Figure 2 represents a configuration of a typical base station antenna, according to prior art, comprising n radiating elements in the horizontal plane and m radiating elements in the vertical plane ;
- Figure 3 represents an antenna arrangement of three dual-polar radiating elements aligned horizontally (n=3) according to prior art ;
- Figure 4 represents an antenna arrangement comprising a single inner dual-polar radiating element and two outer radiating elements (n=3), according to the invention ;
- Figure 5 represents details of a coupling network, according to the invention ;
- Figure 6a and 6b represent achievable azimuth radiation patterns, of an

horizontal arrangement of radiating elements, according to the invention and prior art ;

Figure 3 represents an antenna arrangement according to prior art. This antenna arrangement comprises an inner group of radiating elements 100 and two outer groups of radiating elements 101, 102. Each group of radiating elements 100, 101, 102 comprises a dual-polar radiating element. The group of radiating elements 100, 101, 102 are fed through two power division networks 17, associated with the +45° and -45° polarizations respectively. The radiating elements 100, 101, 102 are aligned horizontally. Each polarization access of the radiating elements 100, 101, 102 is fed through a single power division network 17.

Two variable phase shifters 15 are connected to the inner group of radiating elements 100 and the power division networks 17. Each phase shifter 15 is associated with a single polarization (-45° or +45°). The beamwidth of the antenna is controlled by the choice of the power division ratio provided by the power division networks 17 and the phase shift provided by the phase shifters 15. It is usual that the two polarizations have the same beamwidth and the two phase shifters 15 are varied identically.

It is necessary to excite the two outer groups of radiating elements 101, 102 by only a small proportion of the total input power, typically less than -20dB relative to the inner group of radiating elements 100.

The two power division networks 17 comprise three branches for each of the two radiated polarizations.

This configuration provides a complex and costly antenna with separate power division networks and phase shifters associated with each polarization.

Because the power transmitted by the two outer groups of radiating elements 101, 102 is very much lower than that transmitted by the inner group of radiating elements 100, the polarization characteristics of the outer groups of radiating elements 101, 102 are not critical.

According to a possible embodiment of the present invention, as shown in figure 4, the antenna comprises a set of radiating elements 30 aligned horizontally. The antenna can comprise several sets of radiating elements 30.

Each set of radiating elements 30 includes an inner group of radiating elements 100 and two outer groups of radiating elements 101, 102. In this example, the inner group of radiating elements 100 is a central group of radiating elements 100.

The inner group of radiating elements 100 comprises radiating elements capable of radiating and/or receiving two nominally orthogonally polarized signals.

Nominally means that the signals have planes of polarization inclined nominally ± 45 degrees relative to the vertical plane. The two nominally orthogonally polarized signals can be linear, circular or elliptical.

The signals can be nominally vertically polarized signals, nominally horizontally polarized signals or nominally circularly polarized signals.

The outer groups of radiating elements 101, 102 comprise radiating elements capable of radiating and/or receiving signals with a single polarization.

In this example, each of the two outer groups of radiating elements 101, 102 comprises a single radiating element which is a vertically-polarized radiating element laterally disposed relative to the inner group of radiating elements 100.

The inner group of radiating elements 100 comprises a single dual-polar radiating element. This dual-polar radiating element can be a crossed-dipole radiating element or a patch radiating element.

Each outer group of radiating elements 101, 102 is excited by means of a single power division network 200 with currents of a chosen amplitudes and phases relative to the currents in the dual-polar radiating element of the inner group of radiating elements 100 such that the radiation pattern in the plane containing the groups of radiating elements 100, 101, 102 is modified to provide a chosen 3-dB beamwidth in that plane. The inner group of radiating elements 100 comprises at least two input ports 110, 111, each input 110, 111 of the inner group of radiating elements 100 is connected to one output 211, 212 of the power division network 200.

The dual-polar element of the inner group of radiating elements 100 provides transmission on two orthogonal linear polarizations with polarization planes of +45° and -45° respectively. In order to achieve control of the beamwidth for both polarizations, the signals fed to the outer vertically polarized group of radiating elements 101, 102 are required to contain power from both the transmissions made by the inner dual-polar group of radiating elements 100.

This is achieved by the power division network 200 comprising two inputs 240, 241, each connected to one of the input polarized signals (+45° or -45°). The power division network 200 comprises two outputs 221, 222 each connected to one of the vertically polarized outer group of radiating elements 101, 102. The signals provided at outputs 221, 222 comprise low level signals derived from both of the inputs 240, 241.

The antenna can comprise several variable phase shifters 15.

In the figure 4, the antenna comprises two variable phase shifters 15. Each variable phase shifter 15 is connected to one of the two input ports 110, 111 of the inner group of radiating elements 100 and to one of the outputs 221, 222 of the power division network 200, allowing adjusting the azimuth beamwidth.

There exists many known means by which the functionality of the power division network 200 could be achieved.

Figure 5 provides details of a possible embodiment of the invention in which the power division network 200 is a coupling network 230.

The coupling network 230 comprises two transmission lines 231, 232, each of the transmission lines being connected between one of the input ports 110, 111 of the inner group of radiating elements 100 and one of the input ports 240, 241 of the coupling network 230, respectively.

The coupling network 230 comprises a coupling line 233 having a portion 233a inductively coupled to a portion 231a, 232a of each of the transmission lines 231, 232 of the coupling network 230. The coupling line 233 comprises on one side, a first unconnected end 234 and on the other side, a second end connected to two output lines 112, 113 thereby forming a Tee-junction 235. Each output line 112, 113 is connected to one of the outer radiating elements 101, 102 respectively.

The coupling network 230 can optionally be constructed using any form of radio-frequency transmission line including microstrip lines, striplines or coaxial transmission lines.

In this example, the inner group of radiating elements 100 is a cross polar radiator 100, comprising a crossed dipole, or a dual-polar patch radiating element in which the signals to be radiated with polarizations +45-deg and -45-

degrees are connected to one of the two input ports 110, 111 of the inner group of radiating elements 100, respectively.

Each one of the two RF (Radio Frequency) input ports 240, 241 of the coupling network 230 fed one of the +45-deg and -45-deg input ports 110, 111 of the cross polar radiator 100, respectively.

The unconnected end 234 of the coupling line 233 can be left open-circuit as shown or can be connected to ground via a resistive terminating load. The disposition of the portions 231a, 232a, 233a of the transmission lines 231, 232 and coupling line 233 ensures that a small amount of power from each of portion 231a, 232a of the transmission lines 231, 232 is coupled to the portion 233a of the coupling line 233 but a negligible amount of power is directly coupled between the transmission lines 231 and 232.

The coupling between portions of the transmission lines 231, 232 and the coupling line 233 is chosen such that after passing through the Tee junction 235, the power supplying the outer groups of radiating elements 101, 102 is sufficient to provide the chosen radiation pattern from the antenna. The total relative lengths of the respective portions of the transmission lines 231, 232 and coupling line 233 are chosen such that the radiating signals in each of the radiating elements have an appropriate phase relationship to create the required radiation pattern from the antenna.

The phase of the inner groups of radiating elements 100 can be fixed relative to that in the outer groups of radiating elements 101, 102, creating a chosen fixed azimuth beamwidth.

In one embodiment, the azimuth beamwidth can be made variable by the mean of two variable phase shifters 15 connected between the coupling network 230 and the inner group of radiating elements 100. But from the design of this type of coupler 230, it is advantageous to use a unique variable phase shifter 15 within the coupling line 233 and connected to an input end 236 of the portion 233a of coupling line 233 and the Tee junction 235. The azimuth beamwidth can be adjusted to a chosen value within the range provided by the configuration.

The low relative power level required in the outer groups of radiating elements 101, 102 in order to provide a substantial change in the beamwidth compared with that from the single dual-polar radiating element of the inner group of radiating element 100 ensures that the presence of the vertically-polarized outer groups of radiating elements 101, 102 has little effect on the polarization of the signal radiated by the dual-polar radiating element of the inner group of radiating element 100.

The negligible coupling between the transmission lines 231 and 232 ensures that the isolation between the input ports 241, 242 is very little reduced by the presence of the coupling network 230.

In these respects the performance of the antenna of three radiating elements 100, 101, 102 is very similar to that of an antenna comprising only an isolated dual-polar radiating element, but the composite beamwidth is modified. The performance of the configuration shown in Figure 5, according to the invention, is very close to that provided by the more complex arrangement shown in Figure 3, according to cited prior art, but its cost is reduced and its reliability is increased.

The beamwidths achievable by the means described, according to the invention, range from 65° to 100° according to the choice of complex coupling coefficients between the transmission lines 231, 232 and the coupling line 233.

The antenna arrangement has essentially constant performance over a wide operating frequency band, for example, between 1710 and 2170MHz as shown in Figures 6a and 6b.

Figures 6a and 6b illustrate the adjustable azimuth half-power (3db) beamwidth, in the horizontal plane, of an arrangement as described according to the invention and cited prior art, over the frequency band 1710 – 2170MHz and for the minimum 3 (Figures 6a) and maximum 4 (Figures 6b) beamwidths available from a realisation.

The azimuth half-power (3db) beamwidth 3, 4 can be adjusted when varying the phase with the phase shifter 15.

In an other embodiment, the antenna can comprise no phase shifter. In this case, the azimuth half-power (3db) beamwidth can not be adjusted.

The above description of the invention relates to the simplest realisation in which a single dual-polar radiating element is associated with two outer radiating elements laterally disposed relative to the direction of maximum radiation.

It will be understood by those skilled in the art that this is a particular embodiment and that the method is of general application although the extent of variation in azimuth beamwidth available from arrays with larger number of radiating elements is less then that for the case described.

The inner group of radiating elements 100 and the outer group of radiating elements 101, 102 can comprise several radiating elements.

In a further embodiment, the dual-polar antenna comprises a plurality of set of radiating elements 30 aligned in the vertical plane, forming an antenna array.

This antenna array comprises n radiating elements wide in the horizontal plane (where n has a typical value of 3) and m sets of radiating elements 30 in the vertical plane where m has a value chosen according to the total gain required from the antenna, typically between 4 and 16 sets of radiating elements 30.

This antenna array comprises m coupling networks 230 connected to each of the m sets of radiating elements 30.

Each set of radiating elements 30 could be set to the same azimuth beamwidth value. To vary the azimuth beamwidth of this antenna, it is possible, in a particular embodiment, to couple all the phase shifters 15 together and simultaneously. It is possible to actuate them manually or remotely from the antenna.

Each variable phase shifter 15 can comprise a control device. Each control device is connected to a bus. The bus is linked to a central unit from where signals corresponding to a selected azimuth beamwidth are transmitted to each variable phase shifter 15. The azimuth beamwidth can be controlled with the central unit wherein selected azimuth beamwidth are stored. It can be controlled remotely from the antenna.

Whatever the way the variable phase shifters 15 are actuated, the control device could receive commands from a data communication means provided by wire transmission or wireless transmission in order to remotely change the azimuth beamwidth of the antenna from a location far from the antenna.

According to the Principle of Reciprocity it is well established that the performance characteristics of a passive antenna system, that is one not containing amplifiers or non-linear circuit elements, are the same whether the antenna is used for transmission or reception (for example see “Antennas for all applications", JD Kraus & RJ Marhefka, McGraw-Hill, 3rd edition 2002, p 439).

Specifically the radiation patterns, beamwidths, gains and efficiency of the antenna are identical whether it is transmitting or/and receiving a radio signal. In the above description, to avoid the necessity of describing each component of the antenna system when operating both as a transmitting and as a receiving antenna, the example of a transmitting antenna is used and it is to be understood that in accordance with the said Principle of Reciprocity all aspects of the operation and performance of the arrangement can correspondingly be described in terms of a receiving antenna.

By using a simpler and less costly arrangement of radiating elements and feed networks, one obtain a dual-polar antenna with performance which is in all operational respects equivalent to that which would be provided by the more complex antenna array of identical dual-polar elements together with separate power division networks and phase shifters associated with each polarization.

CLAIMS

1. A dual-polar antenna for a base station of mobile radio systems with adjustable azimuth beamwidth comprising :
   - at least a set of radiating elements (30) comprising :
     - an inner group of radiating elements (100) having at least two input ports (110, 111), and
     - two outer groups of radiating elements (101, 102),
   - the inner group of radiating elements (100) is comprised of radiating elements capable of radiating and/or receiving two nominally orthogonally polarized signals,
   - the outer groups of radiating elements (101, 102) are comprised of radiating elements capable of radiating and/or receiving signals with a single polarization,

   characterised in that :
   - said set of radiating elements (30) comprises a single power division network (200) feeding the inner (100) and outer (101, 102) groups of radiating elements, said single power division network (200) comprising two inputs (240, 241), one for each of the input polarized signals.
2. A dual-polar antenna according to claim 1, characterised in that the inner group of radiating elements (100) comprises a single dual polar radiating element.
3. A dual-polar antenna according to claim 1 or 2 characterised in that the dual polar radiating elements are crossed-dipole radiating elements.
4. A dual-polar antenna according to claim 1 or 2, characterised in that the dual polar radiating elements are patch radiating elements.
5. A dual-polar antenna according to anyone of claims 1 to 4, characterised in that the outer groups of radiating elements (101, 102) comprise each a single radiating element.
6. A dual-polar antenna according to anyone of claims 1 to 5, characterised in that said single power division network (200) of the set of radiating elements (30) comprises :
   - two outputs (211, 212) connected to the two input ports (110, 111) of the inner group of radiating elements (100) respectively,

- two outputs (221, 222), each connected to one of the outer groups of radiating elements (101, 102).

7. A dual-polar antenna according to claim 6, characterised in that it further comprises two variable phase shifters (15), each variable phase shifter (15) being connected to one of the two input ports (110, 111) of the inner group of radiating elements (100) and to one of the two outputs (211, 212) of the power division network (200).

8. A dual-polar antenna according to claim 6, characterised in that the power division network (200) is a coupling network (230) comprising :

- two transmission lines (231, 232), each of the transmission lines being connected between one of the input ports (110, 111) of the inner group of radiating elements (100) and one of the input ports (240, 241) of the coupling network (230), respectively,
- a coupling line (233) having a portion (233a) inductively coupled to a portion (231a, 232a) of each of the transmission lines (231, 232) of the coupling network (230), said coupling line (233) comprising on one side, a first unconnected end (234) and on the other side, a second end connected to two output lines (112, 113) thereby forming a Tee-junction (235), each output line (112, 113) being connected to one of the outer radiating elements (101, 102), respectively.

9. A dual-polar antenna according to claim 8, characterised in that the coupling network (230) comprises a single variable phase shifter (15) within the coupling line (233) and connected to an input end (236) of the inductively coupled portion (233a) of the coupling line (233) and the Tee junction (235).

10. A dual-polar antenna according to anyone of claims 1 to 9, characterised in that it comprises m sets of radiating elements (30) aligned in the vertical plane, forming an antenna array.

11. A dual-polar antenna according to claim 10 as depending upon anyone of claims 7 to 9, characterised in that each variable phase shifter (15) comprises a control device, the control device of each of the variable phase shifters (15) being connected to a bus linked to a central unit, whereby signals corresponding to a selected azimuth beamwidth are transmitted to each variable phase shifter (15) from the central unit.

12. A dual-polar antenna according to claim 11, characterised in that the central unit is linked to a data communication means so that the beamwidth can be remotely controlled.

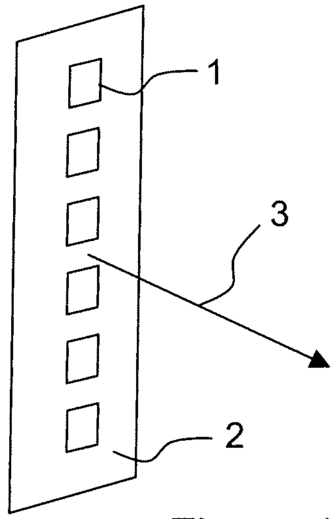

Figure 1
Prior art

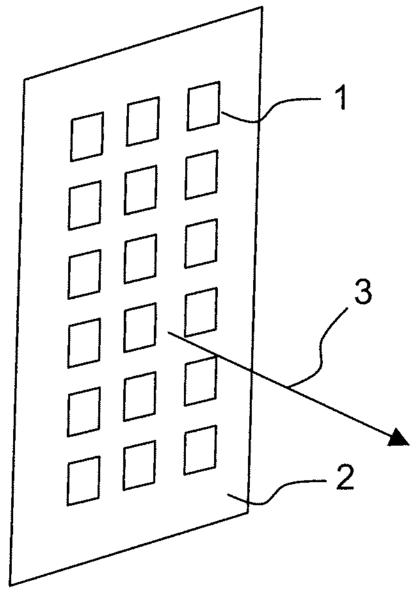

Figure 2
Prior art

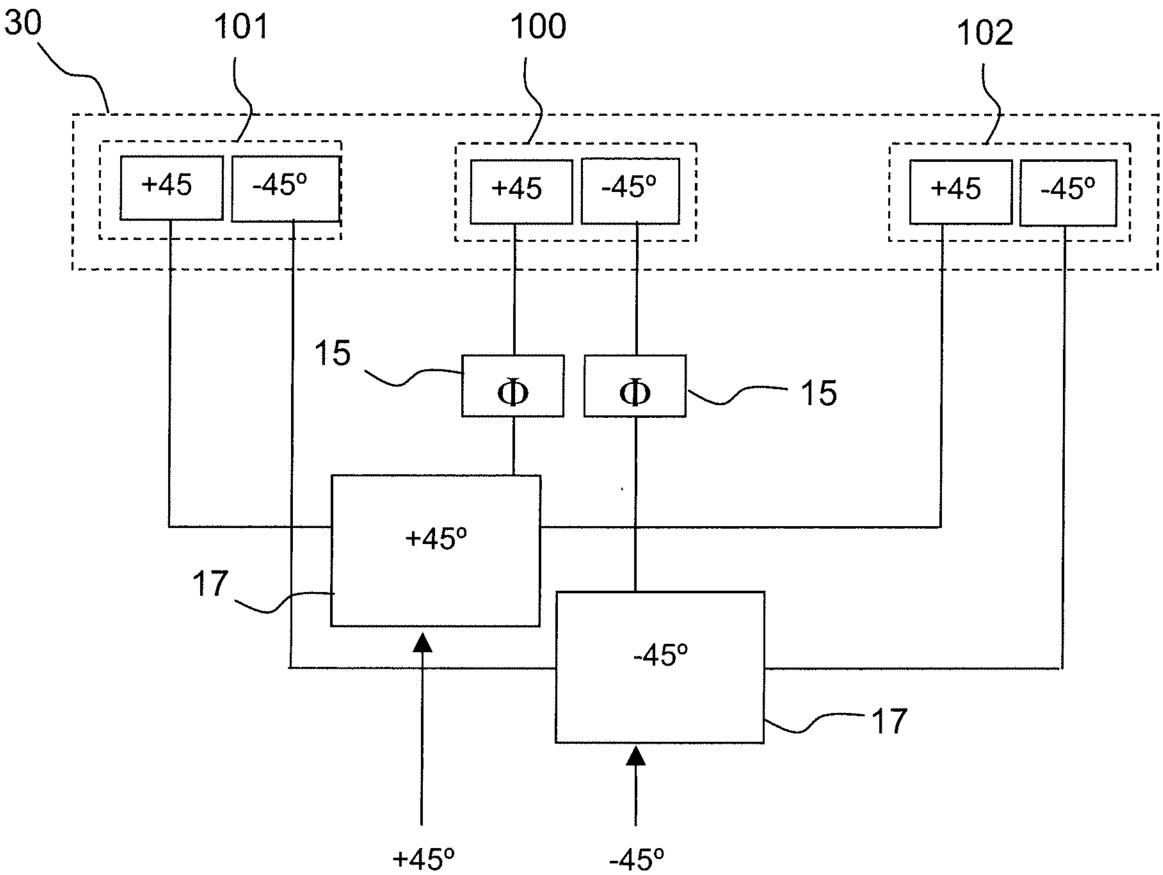

Figure 3
Prior art

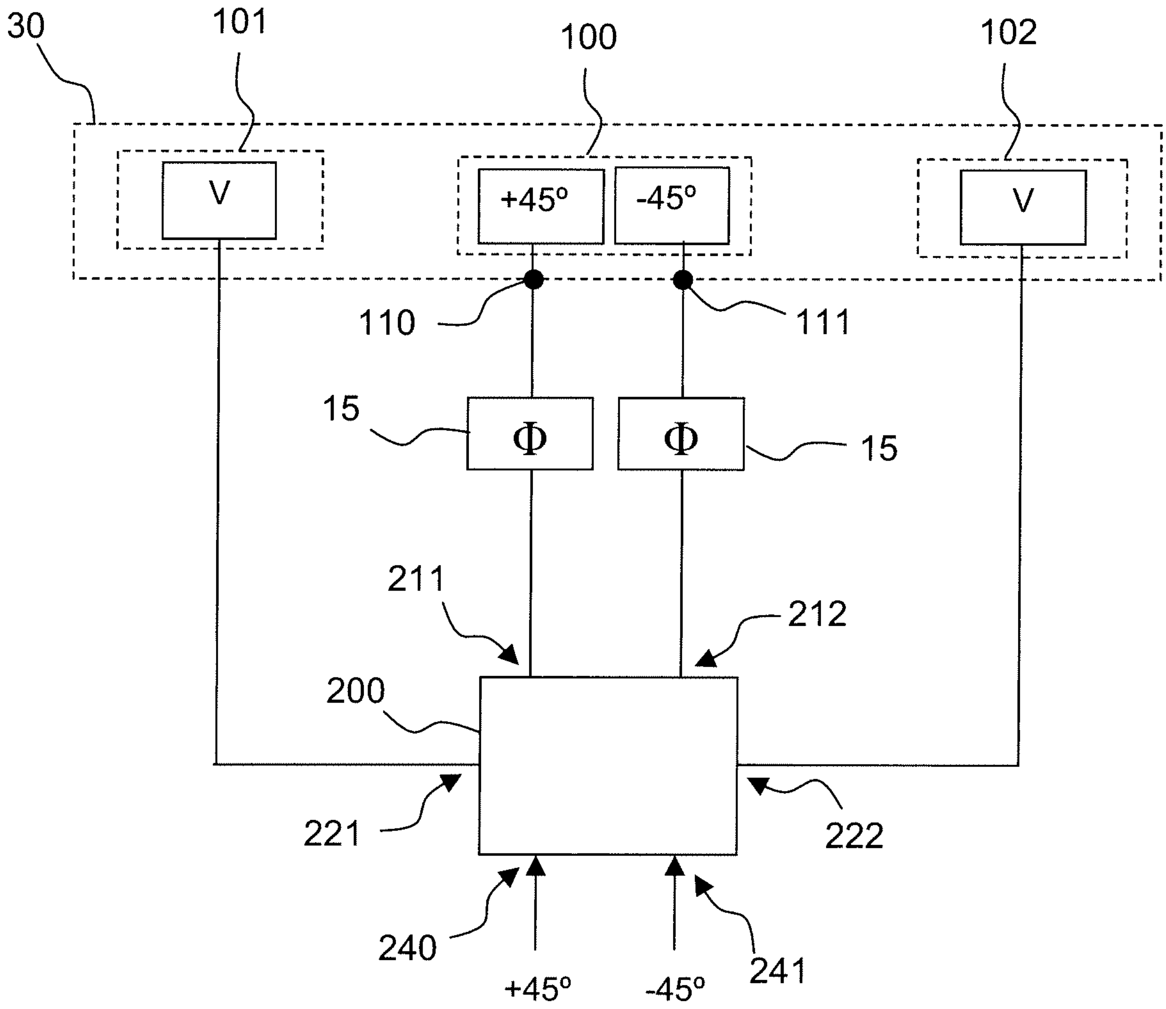
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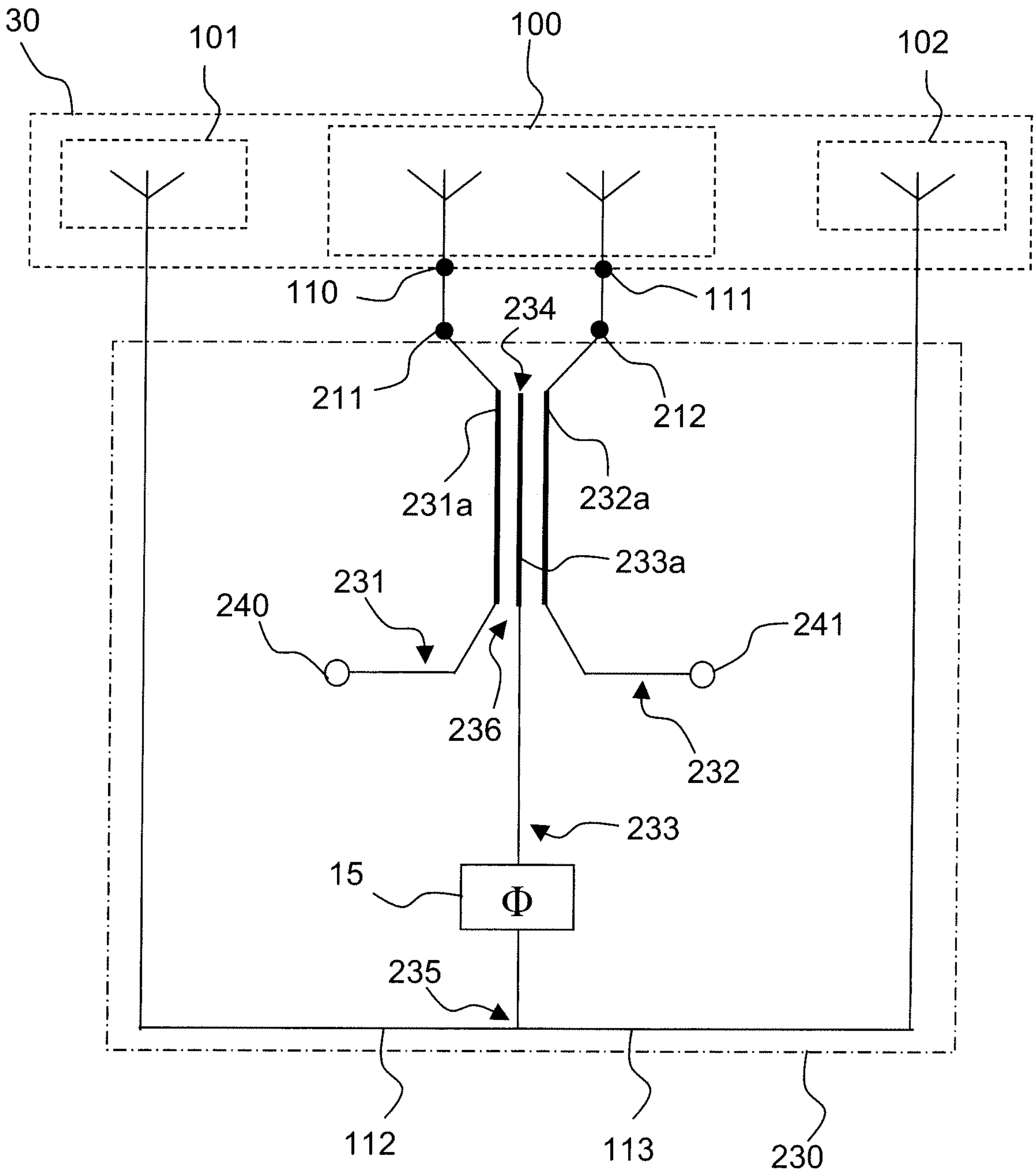
Figure 4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230

Figure 5

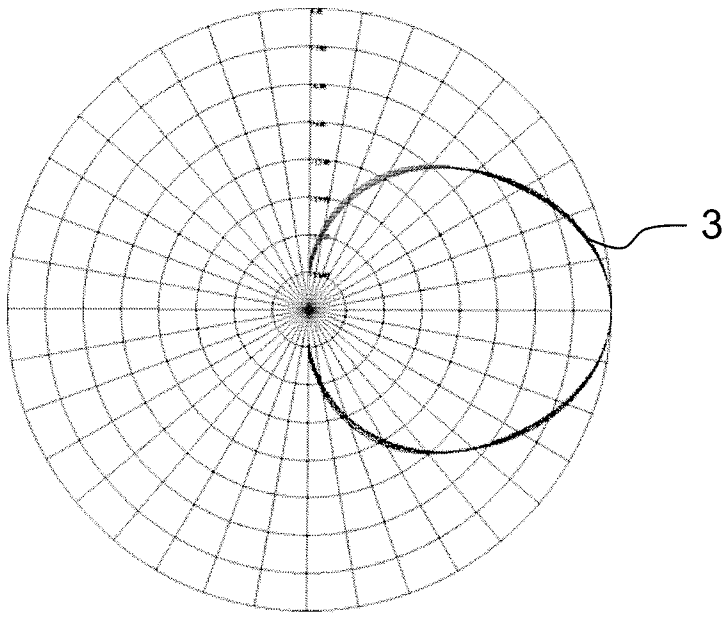

FIGURE 6a

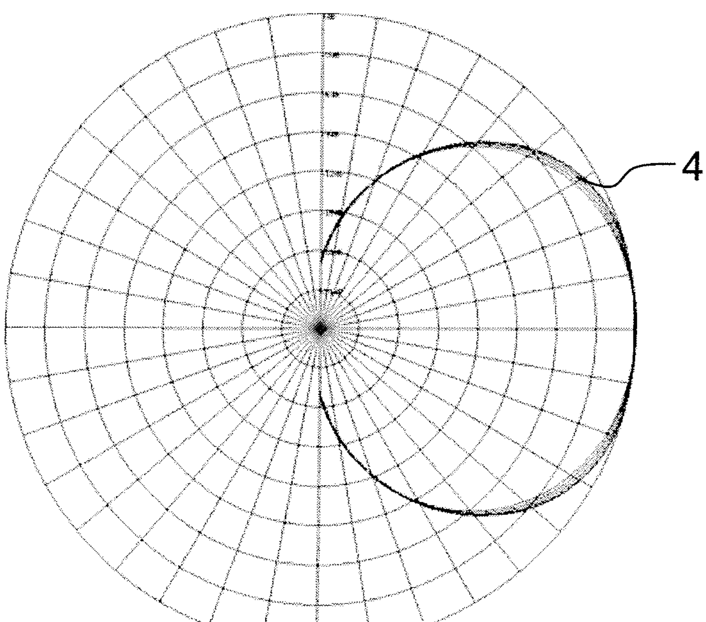

FIGURE 6b

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2007/055538

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01Q21/24 H01Q1/24

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)
H01Q

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 03/034547 A (KATHREIN WERKE KG [DE]; GOETTL MAXIMILIAN [DE]) 24 April 2003 (2003-04-24) page 22, line 21 - page 23, line 23 figure 6	1-7,10 11,12
Y A	WO 02/05383 A (ANDREW CORP [US]; RHODES DANIEL [NZ]; GRAY ANDREW THOMAS [NZ]; JONES D) 17 January 2002 (2002-01-17) page 9, line 5 - page 10, line 29 page 13, lines 20-28 figures 1-4,7,10	11,12 1-10
A	US 5 629 713 A (MAILANDT PETER [US] ET AL) 13 May 1997 (1997-05-13) column 6, line 44 - column 7, line 14 column 8, lines 32-41 figure 6a	1-12

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 September 2007	08/10/2007

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Kruck, Peter

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2007/055538

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

International application No
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