US 20250260177A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2025/0260177 A1

(43) Pub. Date: Aug. 14, 2025

JANG et al.

(54) HYBRID HIGH GAIN ANTENNA ARRAY

(71) Applicant: **JOHN MEZZALINGUA ASSOCIATES, LLC.**, Liverpool, NY (US)

(72) Inventors: **Taehee JANG**, Allen, TX (US); **Gilberto GUERRA ARIAS**, McKinney, TX (US)

(21) Appl. No.: **18/697,671**

(22) PCT Filed: **Feb. 14, 2024**

(86) PCT No.: **PCT/US24/15685**

§ 371 (c)(1),
(2) Date: **Apr. 1, 2024**

Related U.S. Application Data

(60) Provisional application No. 63/485,052, filed on Feb. 15, 2023.

Publication Classification

(51) **Int. Cl.**

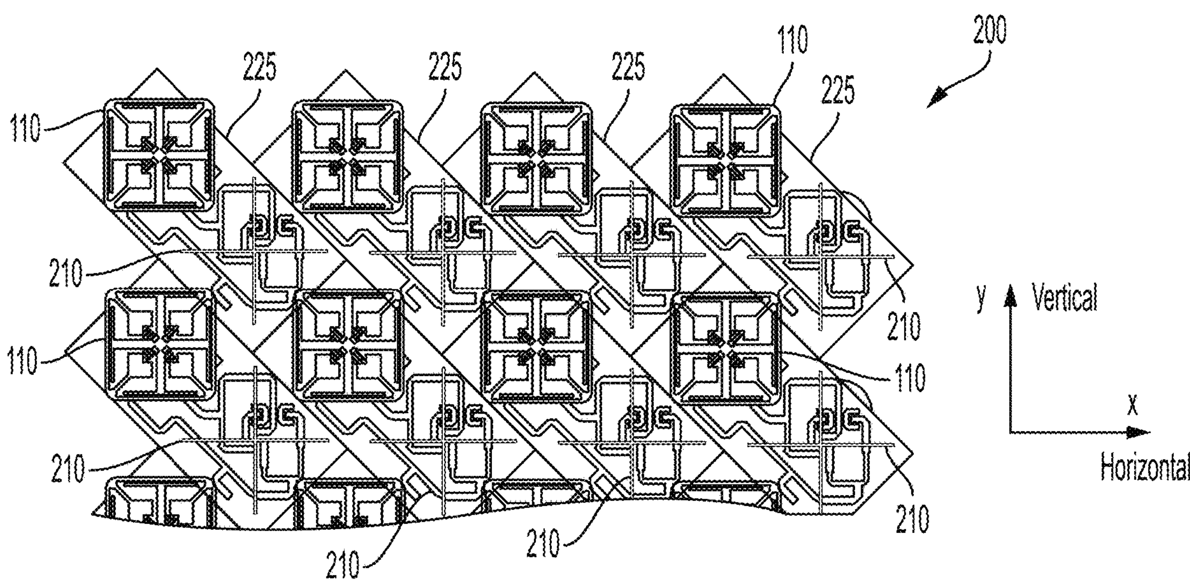
H01Q 21/06 (2006.01)
H01Q 5/48 (2015.01)
H01Q 9/28 (2006.01)
H01Q 19/10 (2006.01)

(52) **U.S. Cl.**

CPC ***H01Q 21/062*** (2013.01); ***H01Q 5/48*** (2015.01); ***H01Q 9/285*** (2013.01); ***H01Q 19/108*** (2013.01)

(57) **ABSTRACT**

A hybrid multiport array antenna comprises a plurality of columns of hybrid dipole unit cells, each of the hybrid dipole unit cells having a first dipole of a first type, and a second dipole of a second type, wherein the first dipole of the first type and the second dipole of the second type are configured to receive a single pair of RF (radio frequency) signals, the pair of RF signals having two orthogonal polarization states, wherein the first dipole of the first type and the second dipole of the second type are spaced with an offset in a vertical direction. The arrangement of the hybrid dipole unit cells reduces the phase center distance between the dipoles in each column and between columns, thereby assuring high gain while reducing grating lobes and other signal gain degradations caused by longer distances between phase centers.



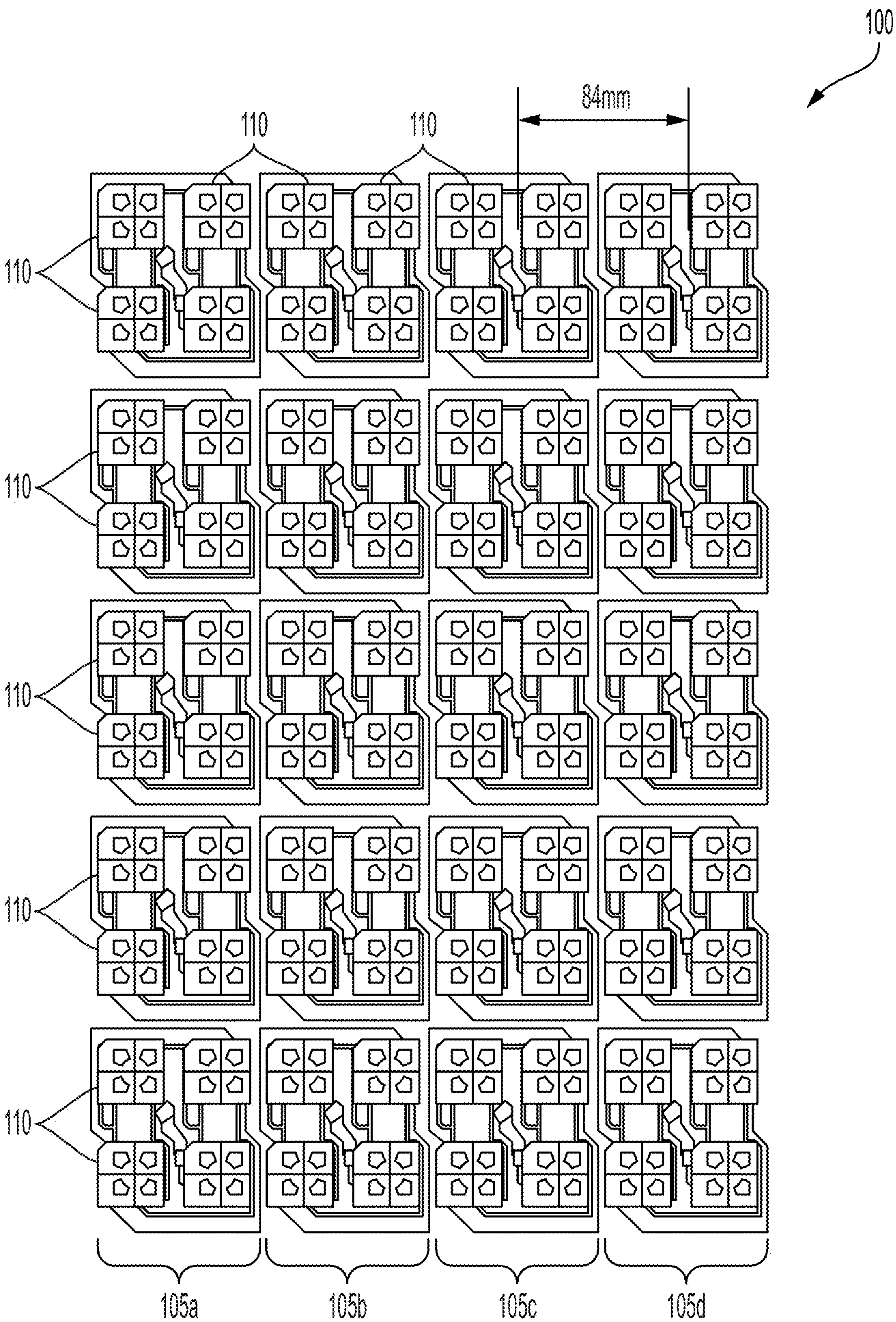


FIG. 1

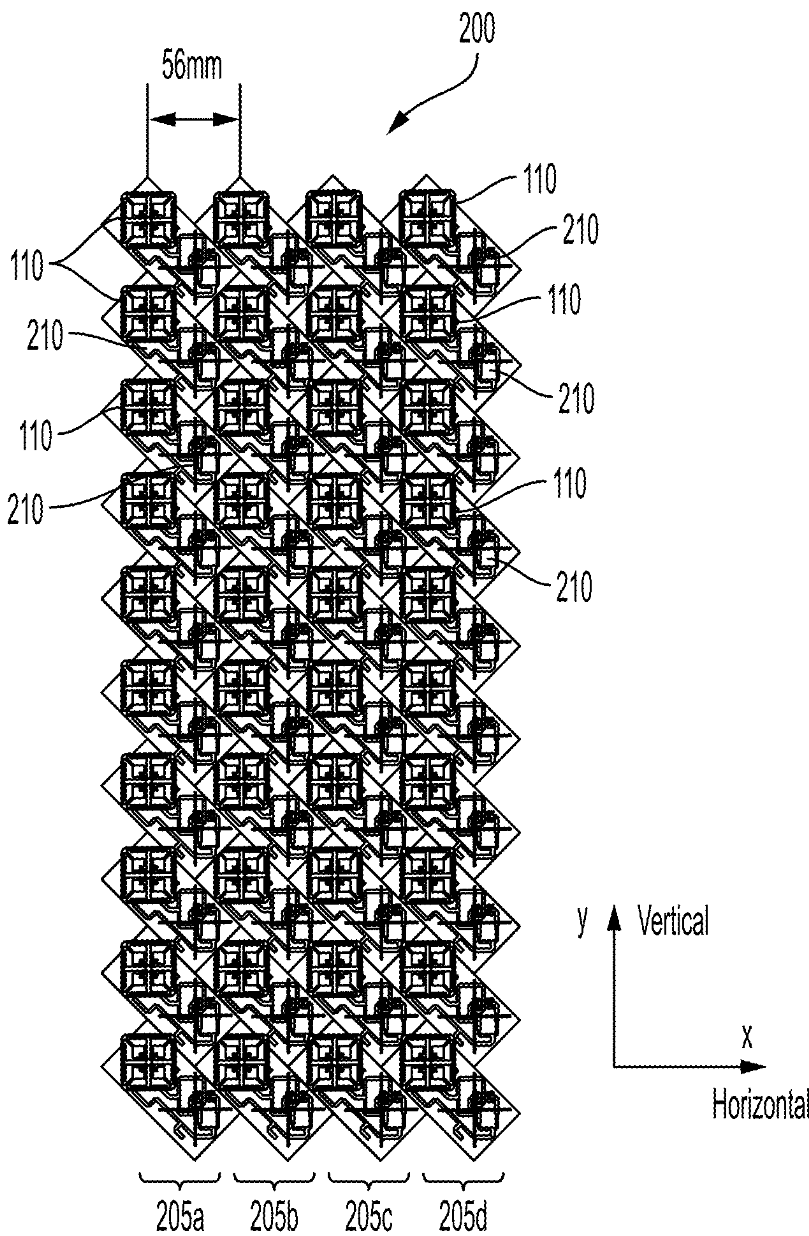

200
56mm
110
210
110
210
110
210
110
210
110
210
y
Vertical
x
Horizontal
205a
205b
205c
205d

FIG. 2A

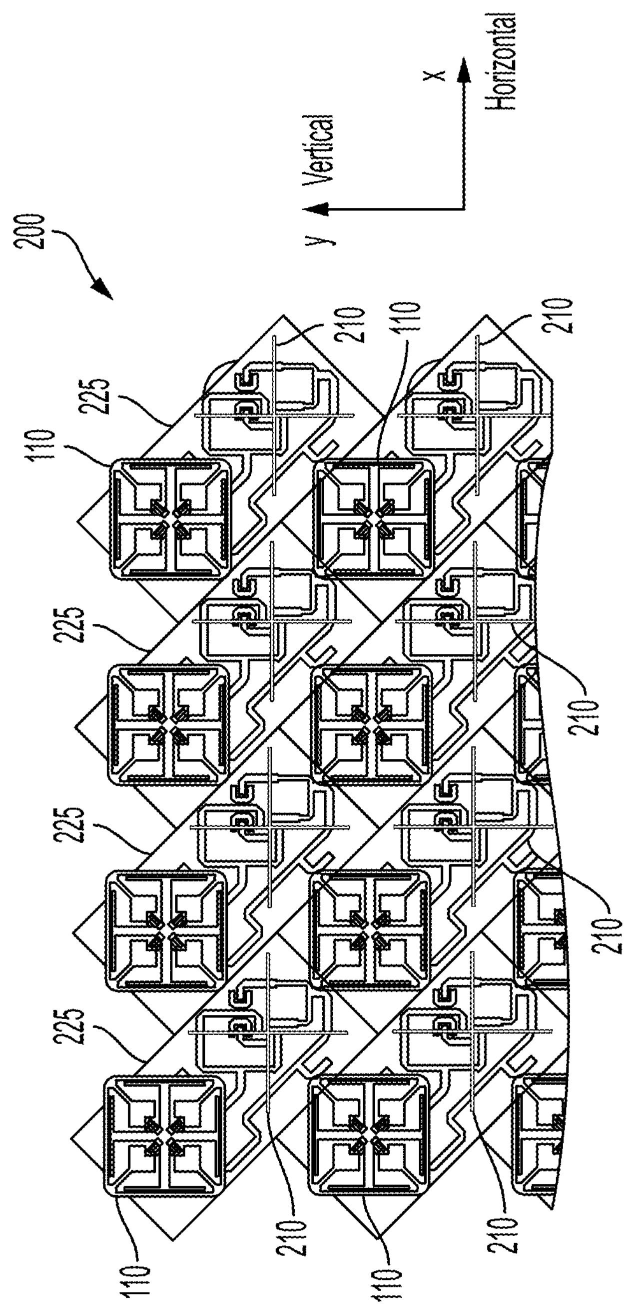

200
y
Vertical
x
Horizontal
110
225
210
110
210
225
225
225
210
210
110
210
110
210

FIG. 2B

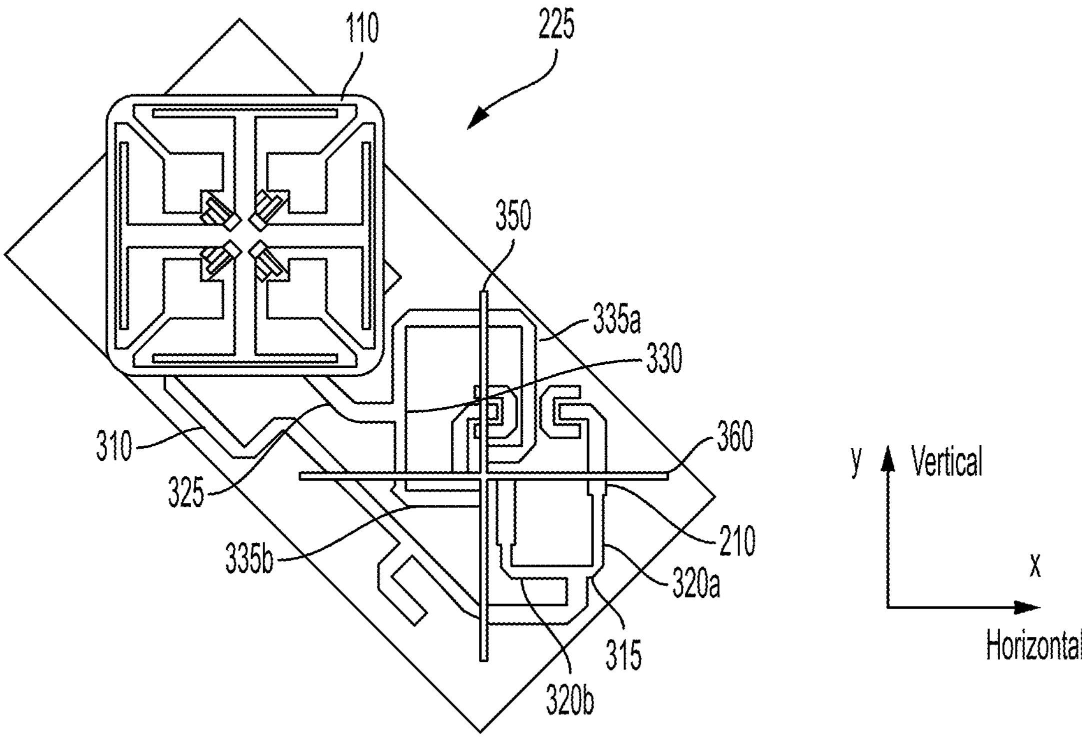

110
225
350
335a
330
310
360
325
y
Vertical
210
335b
x
320a
315
Horizontal
320b

FIG. 3

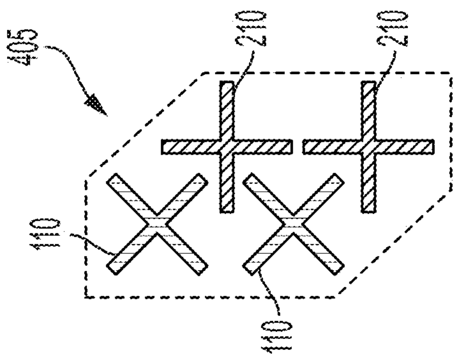


FIG. 4A

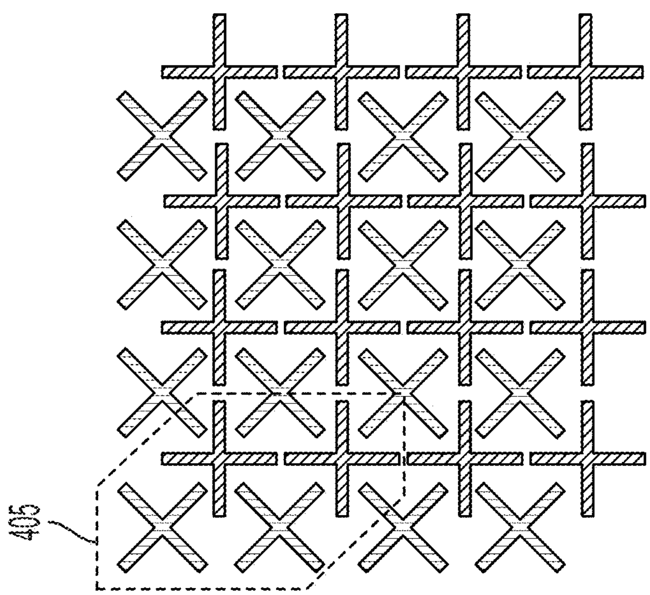


FIG. 4B

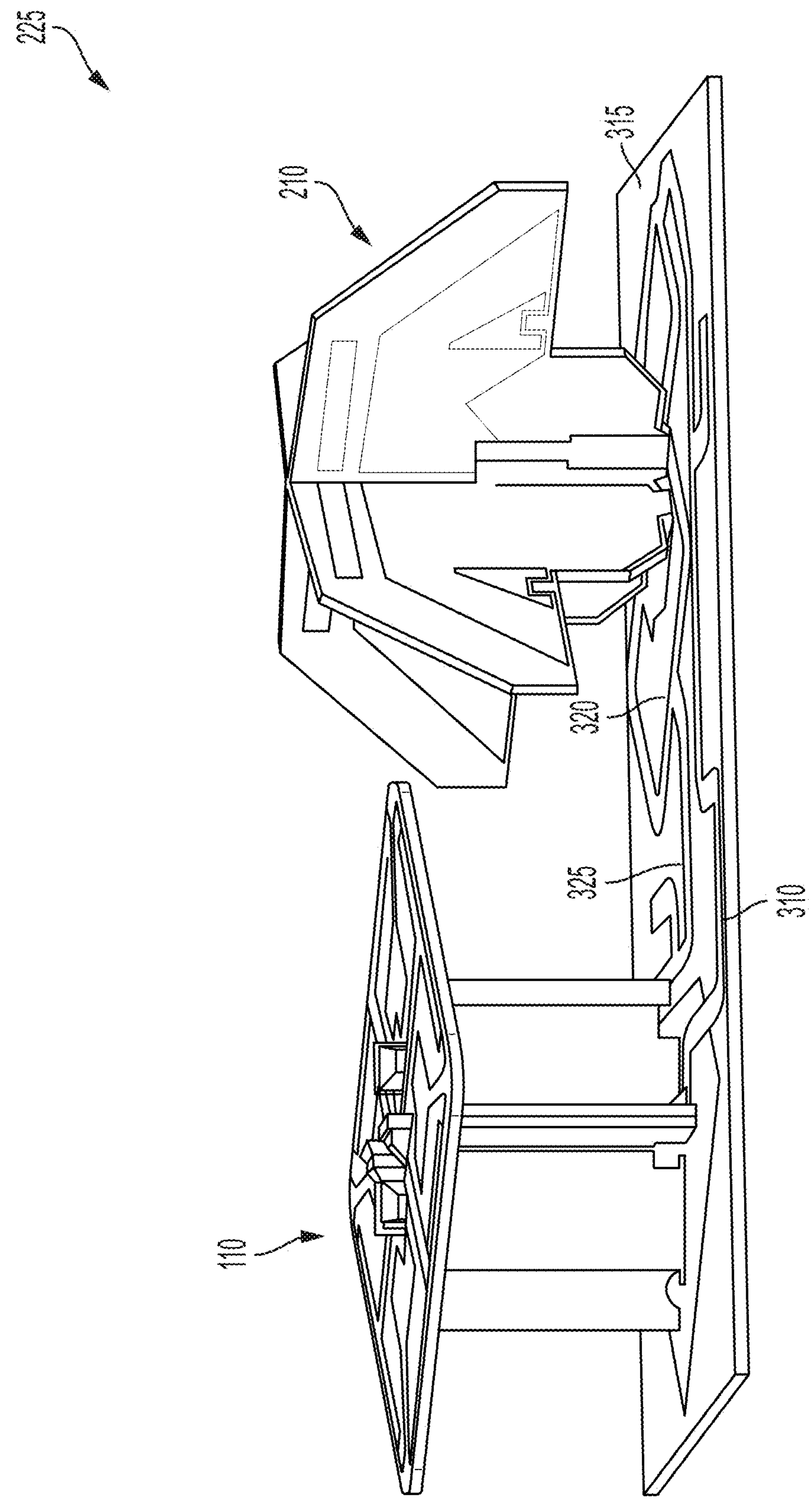


FIG. 5

HYBRID HIGH GAIN ANTENNA ARRAY

BACKGROUND OF THE INVENTION

[0001] Modern cellular antennas typically operate in three frequency bands: low band (LB) (617-896 MHz), mid band (MB) (1695-2690 MHz), C-Band and CBRS (Citizens Broadband Radio Service) (3.4-4.2 GHz). For each of these bands, antennas are required to operate with multiple signals. Common use of the C-Band involves the use of an 8T8R (Eight Transmit Eight Receive) array configuration.

[0002] FIG. **1** illustrates a conventional high gain 8T8R array configuration **100**. Array **100** has eight columns of C-band dipoles **110** arranged into four columns **105***a*, **105***b*, **105***c*, **105***d*, each having two adjacent columns of dipoles **110**. Laterally adjacent dipoles in each of columns **105***a-d* are coupled to a two independent signal sources, one per polarization. Accordingly, with this configuration, array **100** radiates eight distinct RF (Radio Frequency) signals, four per polarization. Array **100** may also have adjacent vertical dipoles **110** arranged in five rows of identically fed dipole clusters (pairs of rows) Each of these clusters may be fed their corresponding signals with a distinct amplitude and phase shift, as provided by a RET (remote electrical tilt) mechanism (not shown) to provide for tilting (i.e., electrically steering) of the antenna beam associated with each column's **105***a-d*) at a distinct tilt angle in the vertical plane defined by the y-axis and z-axis.

[0003] Given that each column **105***a-d* comprises two side-by-side dipoles **110**, the phase center spacing between columns **105***a-d* is 84 mm in this typical example. This phase center distance is relatively long, causing grating lobes to be formed that contaminate the array's gain and beam quality.

[0004] Accordingly, what is needed is a high gain array, such as a C-Band 8T8R array, that has high gain while mitigating grating lobes endemic to conventional solutions.

SUMMARY OF THE INVENTION

[0005] An aspect of the present disclosure involves a multiport array antenna. The multiport array antenna comprises a plurality of columns of hybrid dipole unit cells, each of the hybrid dipole unit cells having a first dipole of a first type, and a second dipole of a second type, wherein the first dipole of the first type and the second dipole of the second type are configured to receive a single pair of RF (radio frequency) signals, the pair of RF signals having two orthogonal polarization states, wherein the first dipole of the first type and the second dipole of the second type are spaced with an offset in a vertical direction.

[0006] Throughout this disclosure, the terms "vertical direction" and "horizontal directions" are used. It will be understood that these terms are not intended to be construed as absolute. Thus, "vertical direction" is not intended to mean in an absolute up or down direction; rather, it is intended to include reasonable variations from absolute vertical as understood by those skilled in the art at the time of this disclosure. For example, the vertical direction may allow for an antenna to be mounted at a tilt angle around the x-axis. Likewise, "horizontal direction" is not intended to mean absolute level; rather, it is intended to include reasonable variations from absolute level as understood by those skilled in the art at the time of this disclosure.

[0007] In another aspect of the present disclosure, a multiport antenna comprises a plurality of dipole columns, each dipole column having a first sub-column having first dipoles of a first type and a second sub-column having second dipoles of a second type, wherein the first dipoles of the first type and the second dipoles of the second type are configured to radiate in a first frequency band, wherein the first dipoles of the first type within a corresponding first sub-column and the second dipoles of the second type within a corresponding second sub-column are coupled to a common signal source.

BRIEF DESCRIPTION OF DRAWINGS

[0008] FIG. **1** illustrates a high gain 8T8R C-Band array.

[0009] FIG. **2**A illustrates an exemplary hybrid high gain 8T8R array according to the disclosure.

[0010] FIG. **2**B is a zoomed in view of the exemplary hybrid high gain 8T8R array of FIG. **2**A.

[0011] FIG. **3** illustrates an exemplary hybrid dipole unit cell, along with an exemplary feed network, according to the disclosure

[0012] FIG. **4**A illustrates a single signal and phase dipole cluster according to the disclosure

[0013] FIG. **4**B is a diagram illustrating an exemplary arrangement of first and second dipole types according to the disclosure.

[0014] FIG. **5** is another view of exemplary hybrid dipole unit cell.

DETAILED DESCRIPTION OF THE INVENTION

[0015] FIG. **2**A illustrates an exemplary hybrid high gain 8T8R array **200** according to the disclosure. Hybrid array **200** has four first columns of first C-Band dipoles **110** and four interlaced second columns of second C-Band dipoles **210** that are arranged in merged dipole columns **205***a*, **205***b*, **205***c*, and **205***d*. As illustrated, each of exemplary merged dipole columns **205***a-d* has ten hybrid dipole unit cells, each of which are arranged diagonally and having one first dipole **110** and one second dipole **210**. With the diagonal orientation of each hybrid dipole unit cell and the use of a first dipole **110** and second dipole **210** in alternating columns, phase center spacing may be reduced. In this example, the phase center spacing may be 56 mm. This sharp reduction in phase center spacing substantially mitigates the grating lobes characteristic of array **100**. As illustrated, merged dipole columns **205***a-d* are arranged along a horizontal axis.

[0016] FIG. **2**B is a zoomed in view of FIG. **2**A, showing eight hybrid dipole unit cells **225**, each having one first dipole **110** and one second dipole **210**. Each of the first dipole **110** and second dipole **210** of each hybrid dipole unit cell **225** is fed two RF signals, one per polarization. Each hybrid dipole unit cell **225** in a given column is fed the same two RF signals.

[0017] FIG. **3** illustrates a single hybrid dipole unit cell **225** according to the disclosure. Hybrid dipole unit cell **225** has a single first dipole **110** and a single second dipole **210** having a vertical stem panel **350** and a horizontal stem panel **360**; a first signal feed **310** that couples a first RF signal (e.g., +45 degree polarization) to the appropriate dipole arms of first dipole **110**; and a second feed **325** that couples a second RF signal (e.g., −45 degree polarization) to the other dipole arms of first dipole **110**. First feed **310**, in addition to coupling to first dipole **110**, also couples to the appropriate dipole arms (e.g., corresponding to +45 degree polarization) of second dipole **210** via a power divider **315**, which splits the RF signal into a first longer trace branch **320***a* and a first shorter trace branch **320***b*. First longer trace branch **320***a* couples to a first side (i.e., the upper side as viewed in FIG. **3**) of horizontal stem plate **360** of second dipole **210**. First shorter trace branch **320***b* couples to a second side (i.e., the lower side as viewed in FIG. **3**) of horizontal stem plate **360** of second dipole **210**. The difference in length of first longer trace branch **320***a* and first shorter trace branch **320***b* may be established so that the difference in phase between the RF signal present where first longer trace branch **320***a* is coupled to first side of horizontal stem plate **360** and the RF signal where first shorter trace branch **320***b* is coupled to the second side of horizontal stem plate **360** is 180 degrees. Accordingly, a 180 phase difference between where the signal meets the two sides of horizontal stem plate **360** contributes to a 45 degree rotation of the transmitted signal. What is not shown in FIG. **3** is that a conductor on the first side of horizontal stem plate **360**, to which first longer trace branch **320***a* couples, extends to and along a second side (i.e., the left side as viewed in FIG. **3**) of vertical stem plate **350** in the positive vertical direction from horizontal stem plate **360**. Also not shown in FIG. **3** is that a conductor on the second side of horizontal stem plate **360**, to which first shorter trace branch **320***b* couples, extends to and along a first side (i.e., the right side as viewed in FIG. **3**) of vertical stem plate **350** in the negative vertical direction from horizontal stem plate **360**.

[0018] Second feed **325** feeds the second RF signal (e.g., −45 degree polarization) to second dipole **210** via a power divider **330**, which splits the second RF signal into a second longer trace branch **335***a* and a second shorter trace branch **335***b*. Second longer trace branch **335***a* couples to the first side of vertical stem plate **350** of second dipole **210**. Second shorter trace branch **335***b* couples to the second side of vertical stem plate **350** of second dipole **210**. The difference in length of second longer trace branch **335***a* and second shorter trace branch **335***b* may be established so that the difference in phase between the RF signal present where second longer trace branch **335***a* is coupled to the first side of vertical stem plate **350** and the RF signal where second shorter trace branch **335***b* is coupled to the second side of vertical stem plate **350** is 180 degrees. Accordingly, a 180 degree phase difference between where the second RF signal meets the two sides of vertical stem plate **350** contributes to a 45 degree rotation of the transmitted signal. What is not shown in FIG. **3** is that a conductor on the first side of vertical stem plate **350**, to which first longer trace branch **335***a* couples, extends to and along the first side of horizontal stem plate **360** in the positive horizontal direction from vertical stem plate **350**. Also not shown in FIG. **3** is that a conductor on the second side of vertical stem plate **350**, to which second shorter trace branch **335***b* couples, extends to and along the second side of horizontal stem plate **360** in the negative horizontal direction from vertical stem plate **350**.

[0019] The arrangement of coupling of first longer trace branch **320***a*, first shorter trace branch **320***b*, second longer trace branch **335***a* and second shorter trace branch **335***b*, as well as their respective trace lengths, may feed the two corresponding RF signals to the stem plates **350**/**360** such that the two RF signals achieve phase shifts sufficient to rotate the polarization of the first and second signals by 45 degrees. Accordingly, although the dipole arms of second dipole **210** are horizontal and vertical (as shown), they radiate the first RF signal at a +45 degree polarization and the second RF signal at a −45 degree polarization. As illustrated, hybrid dipole unit cell **225** may be oriented so that the first dipole **110** and second dipole **210** are positioned with an offset along the vertical (y) axis, enabling them to be located more closely together in the horizontal (x) axis.

[0020] This rotation of a radiated signal from horizontal and vertical dipole arms to +/−45 degree radiated energy is also described in co-owned U.S. Pat. No. 11,158,956, INTEGRATED FILTER RADIATOR FOR A MULTIBAND ANTENNA, which is incorporated by reference is if fully disclosed herein.

[0021] FIG. **4**A illustrates a single signal and phase dipole cluster **405** according to the disclosure. A signal and phase dipole cluster **405** may have two hybrid dipole unit cells **225**, arranged vertically in a given column **205***a/b/c/d*. A given single signal and phase dipole cluster **405** is fed two RF signals (one per polarization), and those two RF signals have a single phase, which means that a single signal and phase dipole cluster **225** is coupled to the output of a single phase shifter (not shown).

[0022] FIG. **4**B illustrates how a single signal and phase dipole cluster **405** may be integrated to form array **200**.

[0023] Referring to FIG. **2**, each column **205***a/b/c/d* may have five single signal and phase dipole clusters. The constituent single signal and phase dipole clusters **405** of a given column **205***a/b/c/d* are fed the same two RF signals (one per polarization) but each may have a different phase difference imparted by a corresponding phase shifter (not shown) so that the beam formed by the given column **205***a/b/c/d* may be tilted up and down in the vertical (y) axis.

[0024] FIG. **5** further illustrates hybrid dipole unit cell **225**. Shown are first dipole **110**; second dipole **210**, first feed **310**, which splits at power divider **315**; and second feed **325**, which splits at power divider **330**.

[0025] While the present disclosure has been described in terms of exemplary exemplary embodiments, those skilled in the art at the time this disclosure would know and appreciate that other exemplary embodiments are possible and within the spirit and understanding of this disclosure.

1. A multiport antenna array, comprising:

a plurality of columns of hybrid dipole unit cells, each of the hybrid dipole unit cells having a first dipole of a first type, and a second dipole of a second type,

wherein each of the first dipole of the first type and the second dipole of the second type are configured to receive a single pair of RF (radio frequency) signals, the pair of RF signals corresponding to two orthogonal polarization states, wherein the first dipole of the first type and the second dipole of the second type are spaced with an offset in a vertical direction.

2. The multiport antenna array of claim **1**, wherein the first dipole of the first type and the second dipole of the second type are configured to operate in a single frequency band.

3. The multiport antenna array of claim **2**, wherein the single frequency band comprises a C-Band.

4. The multiport antenna array of claim **2**, wherein each of the hybrid dipole unit cells comprises:

a first signal feed coupled to a first dipole arm of the first dipole of the first type and coupled to a first power divider; and a second signal feed coupled to a second dipole arm of the first dipole of the first type and coupled to a second power divider.

5. The multiport antenna array of claim **4**, wherein the first power divider is coupled to a first longer trace branch, wherein the first longer trace branch is coupled to a first side of a horizontal stem plate of the second dipole of the second type, and wherein the first power divider is coupled to a first shorter trace branch, wherein the first shorter trace branch is coupled to a second side of the horizontal stem plate of the second dipole of the second type.

6. The multiport antenna array of claim **5**, wherein the second power divider is coupled to a second longer trace branch, wherein the second longer trace branch is coupled to a first side of a vertical stem plate of the second dipole of the second type, and wherein the second power divider is coupled to a second shorter trace branch, wherein the second shorter trace branch is coupled to a second side of the vertical stem plate of the second dipole of the second type.

7. The multiport antenna array of claim **1**,

wherein the hybrid dipole unit cells, of each of the plurality of columns of hybrid dipole unit cells, are arranged into a plurality of single signal and phase dipole clusters, each single signal and phase dipole cluster comprising at least two hybrid dipole unit cells; and

wherein the pair of RF signals have a single phase.

8. The multiport antenna array of claim **1**,

wherein the hybrid dipole unit cells, of each of the plurality of columns of hybrid dipole unit cells, are arranged into a plurality of single signal and phase dipole clusters, each single signal and phase dipole cluster comprising at least two hybrid dipole unit cells; and

wherein the RF signals that make up the pair of RF signals associated with at least one of the plurality of single signal and phase dipole clusters have a different amplitude and phase.

9. The multiport antenna array of claim **8** further comprising:

A remote electrical tilt mechanism configured to control the amplitude and phase of the RF signals of the pair of RF signals associated with the at least one of the plurality of single signal and phase dipole clusters and electrically steer, in the vertical direction, an antenna beam associated with the at least one of the plurality of single signal and phase dipole clusters.

10. A multiport antenna array, comprising:

a plurality of dipole columns, each dipole column having a first sub-column having first dipoles of a first type and a second sub-column having second dipoles of a second type, wherein the first dipoles of the first type and the second dipoles of the second type are configured to radiate in a first frequency band, wherein the first dipoles of the first type within a corresponding first sub-column and the second dipoles of the second type within a corresponding second sub-column are coupled to a common signal source.

11. The multiport antenna array of claim **10**, wherein the common signal source comprises:

a first signal corresponding to a first polarization; and

a second signal corresponding to a second polarization.

12. The multiport antenna array of claim **10**, wherein the first dipoles of the first type in the first sub-column and the second dipoles of the second type in the second sub-column have a spatial offset in a vertical direction.

* * * * *