



(19) **United States**

(12) **Patent Application Publication**
RASHIDIAN

(10) **Pub. No.: US 2018/0159247 A1**

(43) **Pub. Date: Jun. 7, 2018**

(54) **ANTENNA ARRAYS WITH COMMON PHASE CENTERS**

(52) **U.S. Cl.**
CPC **H01Q 21/065** (2013.01); **H01Q 15/16** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/40** (2013.01)

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(21) Appl. No.: **15/367,388**

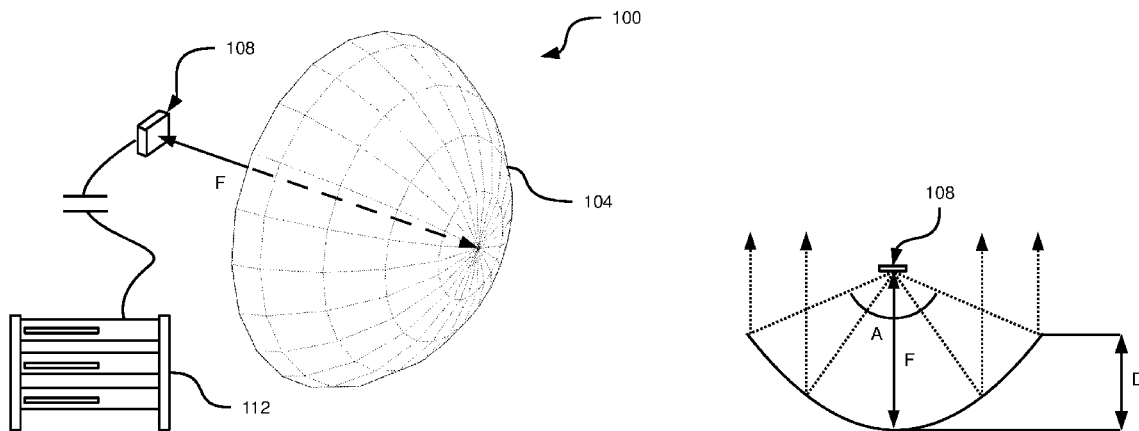
(22) Filed: **Dec. 2, 2016**

(57) **ABSTRACT**

An antenna assembly includes: a support member having opposing first and second sides; an input electrical contact and an output electrical contact; a first array of transmission patch elements supported on the first side and connected to the input electrical contact, the first array configured to receive an input signal via the input electrical contact and generate outbound radiation according to the input signal; a second array of reception patch elements supported on the first side and connected to the output electrical contact, the second array configured to receive inbound radiation and generate an output signal at the output electrical contact according to the inbound radiation; the first array and the second array having a common phase center.

Publication Classification

(51) **Int. Cl.**
H01Q 21/06 (2006.01)
H01Q 1/40 (2006.01)
H01Q 1/48 (2006.01)
H01Q 15/16 (2006.01)



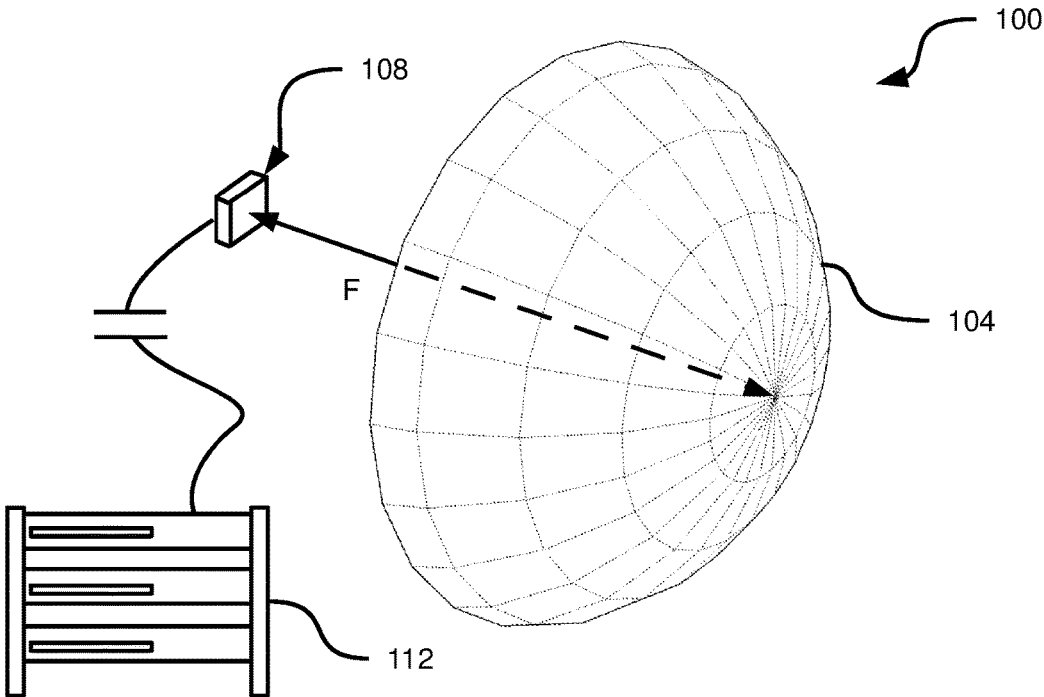


FIG. 1A

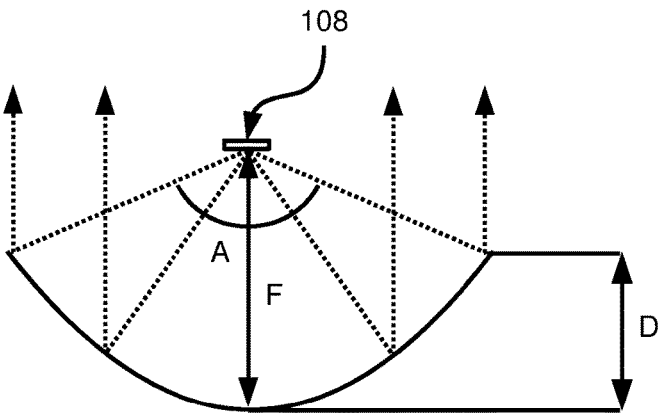


FIG. 1B

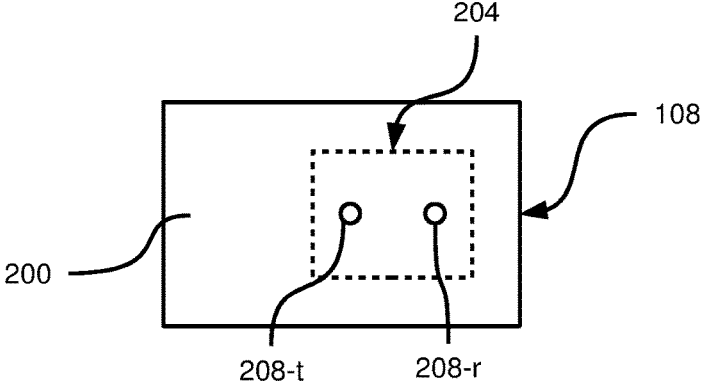


FIG. 2A

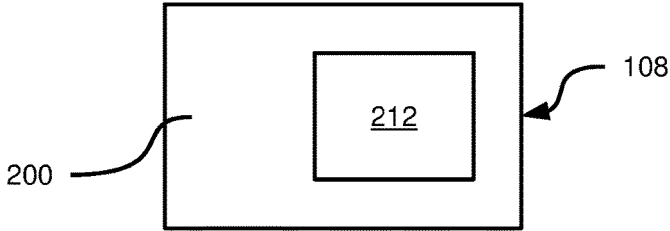


FIG. 2B

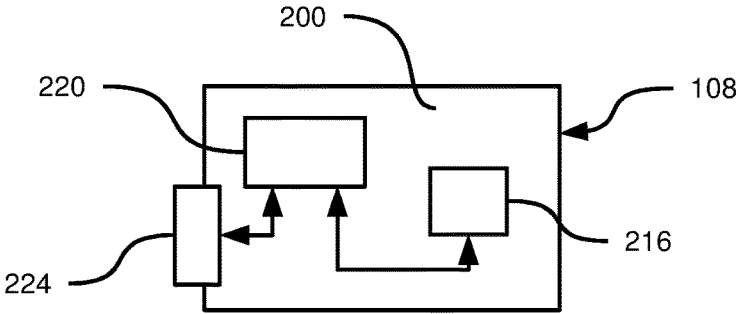


FIG. 2C

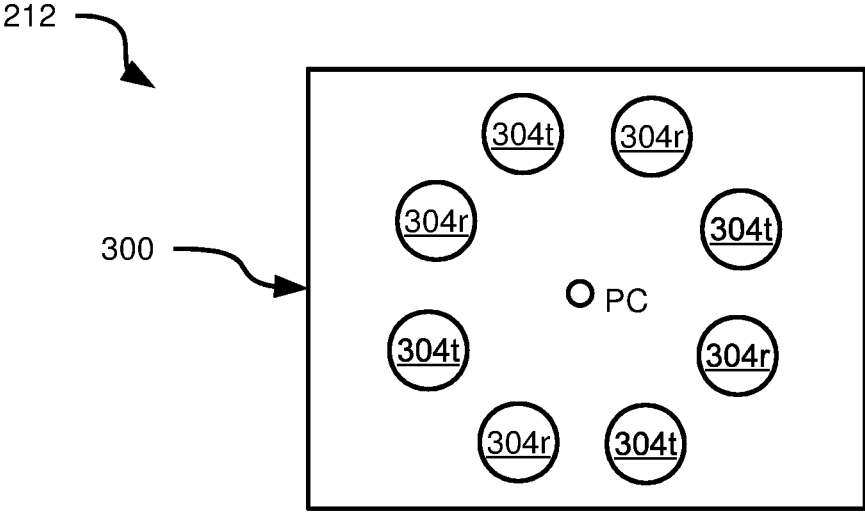


FIG. 3A

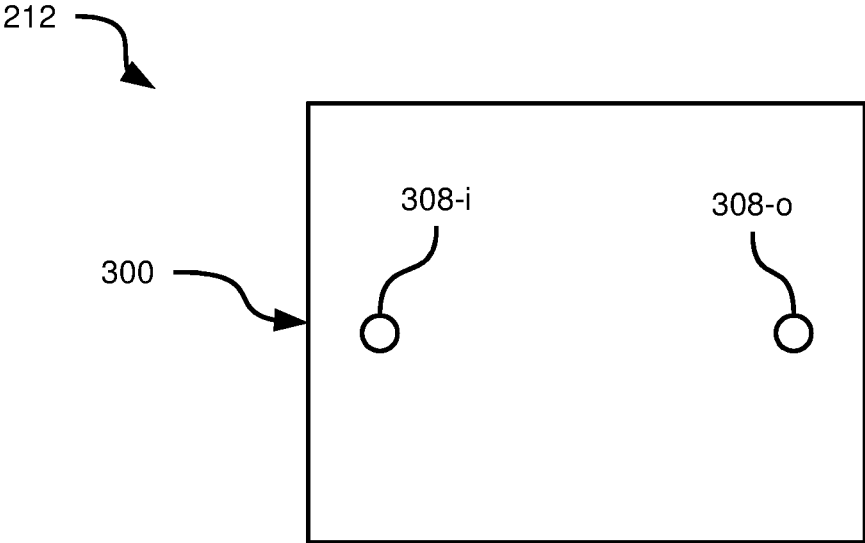


FIG. 3B

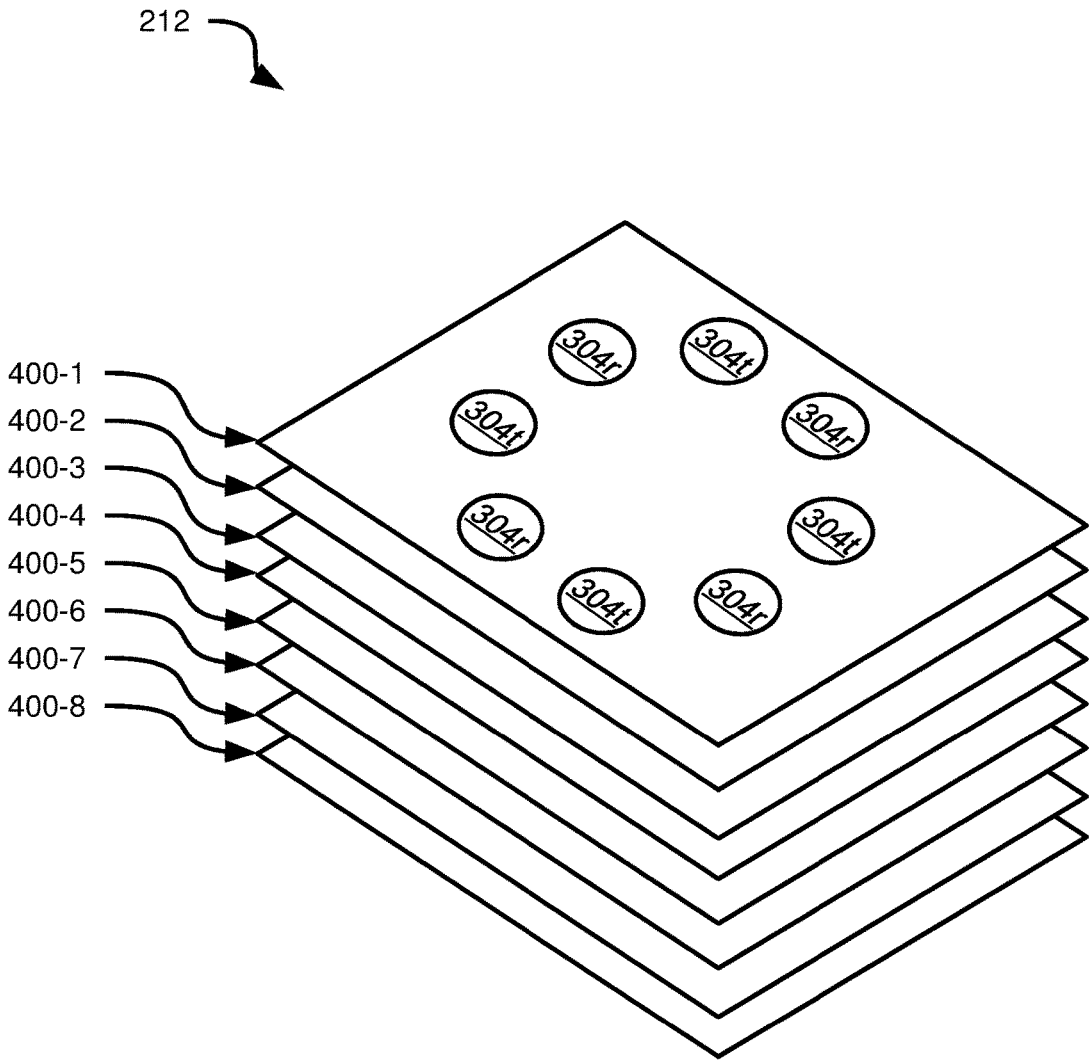


FIG. 4

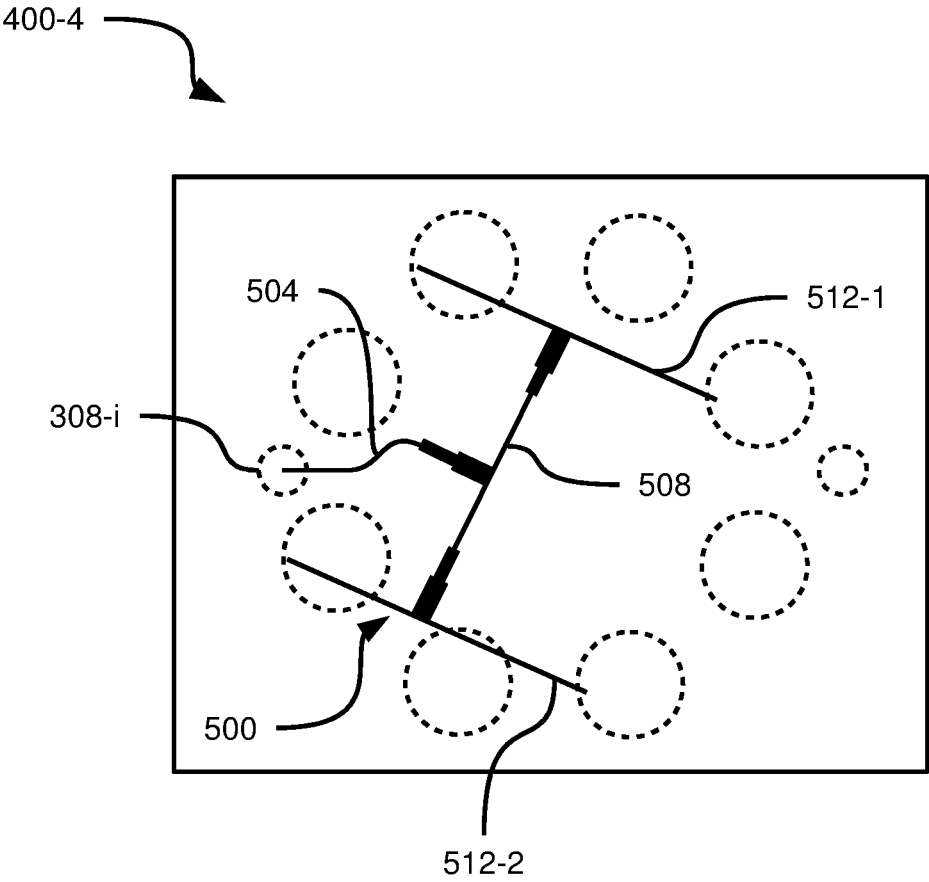


FIG. 5

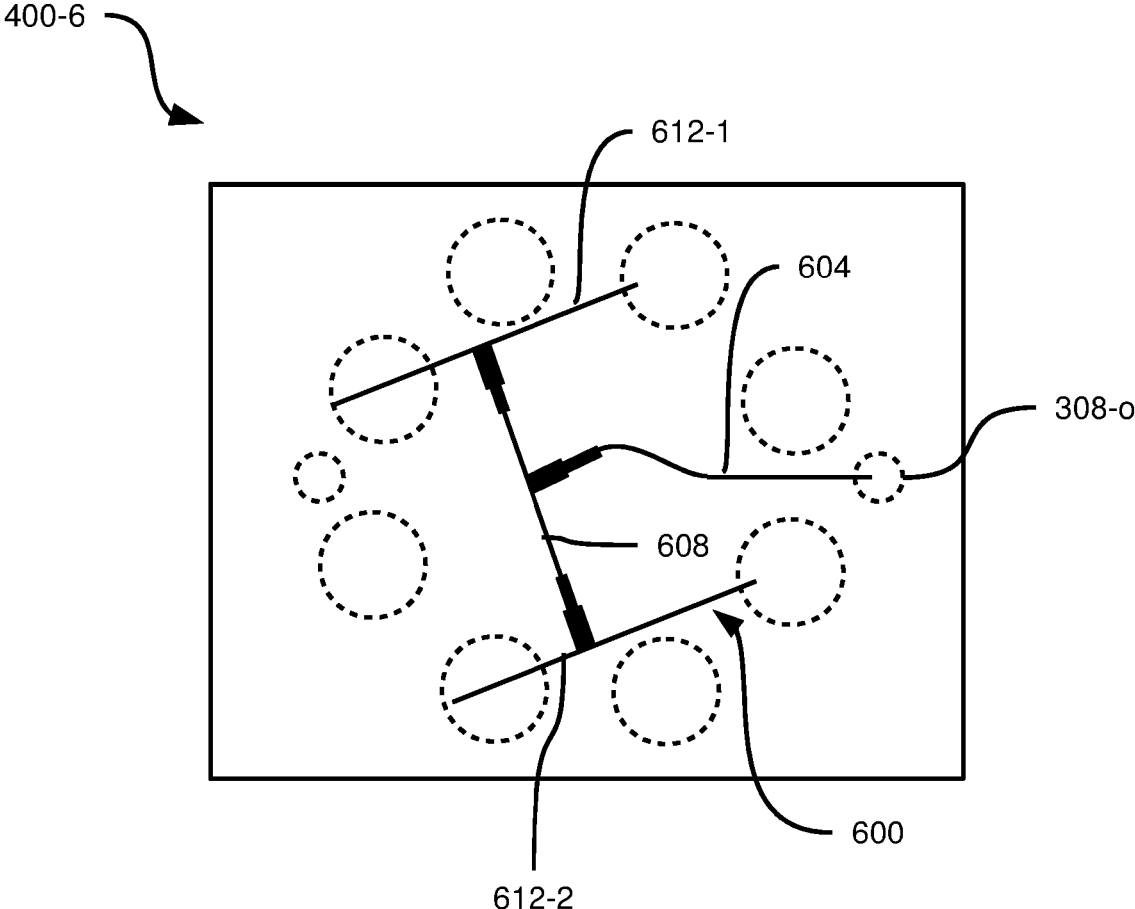


FIG. 6

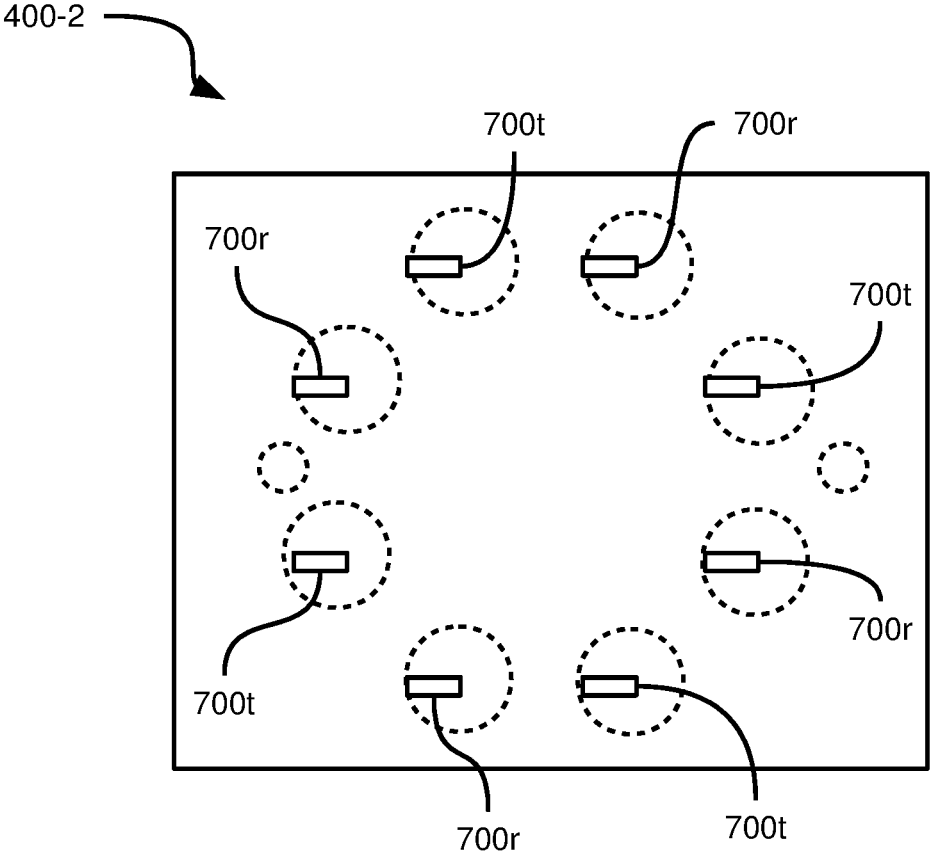


FIG. 7

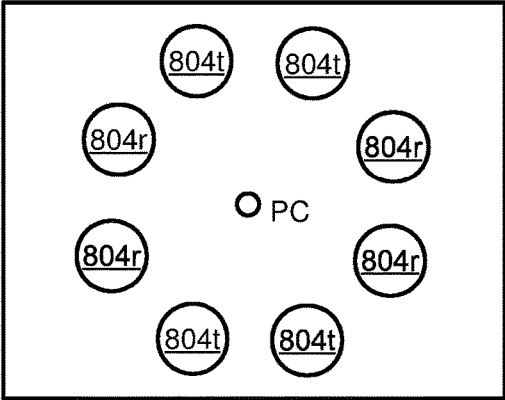
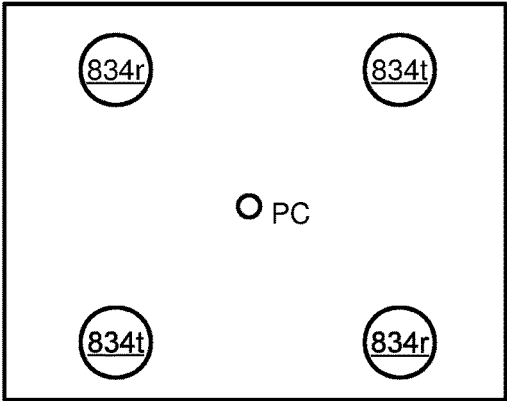


FIG. 8A

812



832

FIG. 8B

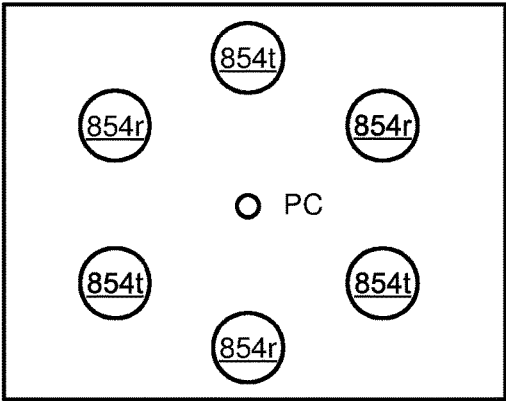


FIG. 8C

852

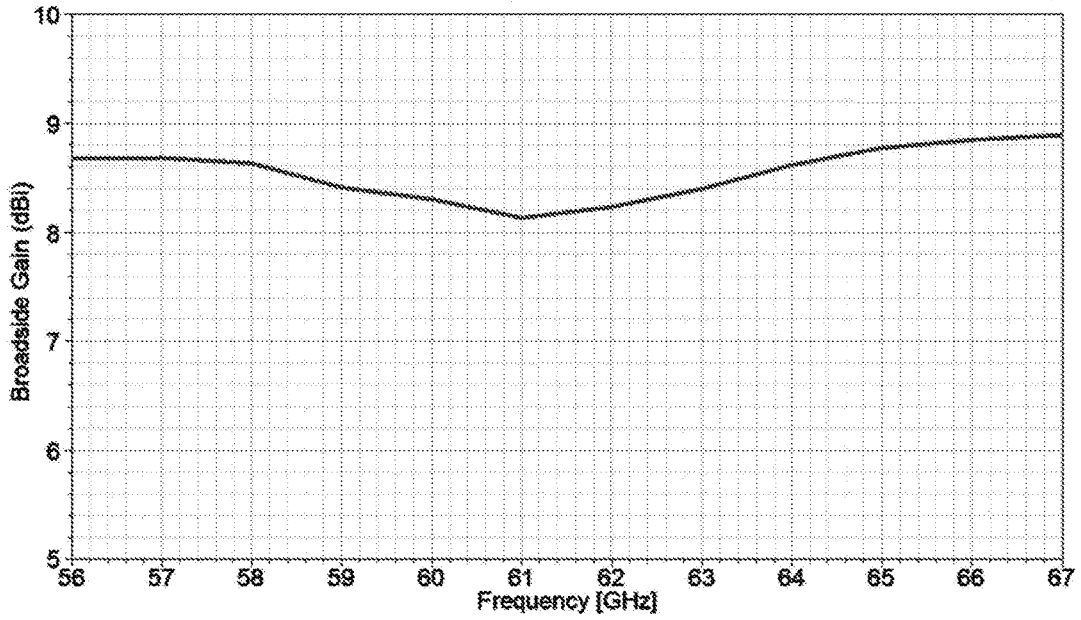


FIG. 9A

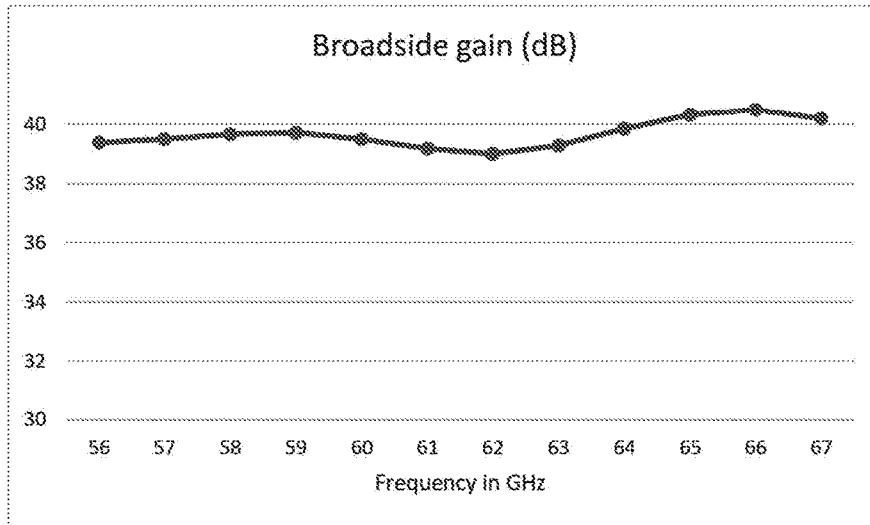


FIG. 9B

ANTENNA ARRAYS WITH COMMON PHASE CENTERS

FIELD

[0001] The specification relates generally to wireless communication, and specifically to antenna arrays with similar phase centers.

BACKGROUND

[0002] In certain wireless communication systems, reflectors are employed with antennas, with the antenna being referred to as a feed for the reflector, in order to increase transmission and reception gain over that provided by the antenna alone. Various design constraints impact the design of antennas for such applications. Such antennas may be required to achieve a certain beamwidth, for example a width sufficient to impact substantially the entire surface of the reflector. It may also be desirable to maximize the gain of the antenna itself. Further, it may be desirable to simplify manufacturing of the antenna, and also to reduce energy losses within the antenna. Existing antenna assemblies leave room for improvement in satisfying the above design constraints while also optimizing antenna performance for use with a reflector.

SUMMARY

[0003] According to an aspect of the specification, an antenna assembly is provided, comprising: a support member having opposing first and second sides; an input electrical contact and an output electrical contact; a first array of transmission patch elements supported on the first side and connected to the input electrical contact, the first array configured to receive an input signal via the input electrical contact and generate outbound radiation according to the input signal; and a second array of reception patch elements supported on the first side and connected to the output electrical contact, the second array configured to receive inbound radiation and generate an output signal at the output electrical contact according to the inbound radiation; the first array and the second array having a common phase center.

[0004] According to another aspect of the specification, a wireless communications assembly is provided, comprising: an assembly support member defining a mounting surface including a transmission electrical contact and a reception electrical contact; a radio processor carried on the assembly support member and connected to the transmission electrical contact and a reception electrical contact; and the antenna assembly of the above-mentioned aspect, the support member coupled to the mounting surface to electrically connect the output electrical contact with the reception electrical contact and the input electrical contact with the transmission electrical contact.

[0005] According to a further aspect of the specification, a communications system is provided, comprising: a parabolic reflector having a focal point; and a wireless communications assembly according to the above-mentioned aspect, supported to position the common phase center of the first array of transmission patch elements and the second array of reception patch elements at the focal point.

BRIEF DESCRIPTIONS OF THE DRAWINGS

[0006] Embodiments are described with reference to the following figures, in which:

[0007] FIGS. 1A and 1B depict perspective and top plan views of a wireless communications system, respectively, according to a non-limiting embodiment;

[0008] FIGS. 2A and 2B depict top plan views of a wireless communications assembly of the system of FIG. 1A, according to a non-limiting embodiment;

[0009] FIG. 2C depicts a bottom plan view of the wireless communications assembly of FIG. 2A, according to a non-limiting embodiment;

[0010] FIGS. 3A and 3B depict top and bottom plan views respectively of an antenna assembly of the wireless communications assembly of FIG. 2A, according to a non-limiting embodiment;

[0011] FIG. 4 depicts the layered structure of the antenna assembly of FIG. 3A, according to a non-limiting embodiment

[0012] FIG. 5 depicts a transmission feed network of the antenna assembly of FIG. 4, according to a non-limiting embodiment;

[0013] FIG. 6 depicts a reception feed network of the antenna assembly of FIG. 4, according to a non-limiting embodiment;

[0014] FIG. 7 depicts a set of intermediate patches of the antenna assembly of FIG. 4, according to a non-limiting embodiment;

[0015] FIGS. 8A, 8B and 8C depict alternative antenna patch arrangements, according to additional non-limiting embodiments; and

[0016] FIGS. 9A and 9B depict performance testing results of an example implementation of the system of FIG. 1A for 60 GHz WiGig applications, according to a non-limiting embodiment.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0017] FIG. 1A depicts a communications system including a parabolic reflector **104**, a wireless communications assembly **108**, and a computing device **112**. In the present embodiment, wireless communications assembly **108** is configured to enable communication using the IEEE 802.11ad standard, and thus transmit and receive data are around 60 GHz. In other embodiments, however, assembly **108** is configured to enable wireless communications in other frequency bands.

[0018] Assembly **108** includes an antenna assembly, which will be discussed in greater detail below, directed towards the concave surface of reflector **104**. Assembly **108** acts as a feed for reflector **104** by receiving data for transmission from computing device **112**, and emitting radiation through excitation of the antenna towards reflector **104**. As will now be apparent, the radiation is aligned and directed by reflector **104**. Assembly **108** also receives incoming radiation that impacts reflector **104** and is focussed by reflector **104** onto the antenna. The incoming radiation is detected by the antenna and the data encoded therein is provided by assembly **108** to computing device **112**.

[0019] Computing device **112** may be any of a wide variety of computing devices. Typically, systems employing reflectors such as reflector **104** are deployed as high-gain backhaul links, and thus computing device **112** is illustrated

as a data center which may, for example, enable communications between wireless devices and the Internet. This implementation is provided simply as an illustrative example, however—a wide variety of computing devices may be employed with system 100, and system 100 may be deployed in any scenario requiring wireless communications (e.g. with other similar systems, with mobile devices such as smartphones, laptop computers and the like, or a combination thereof).

[0020] As seen in FIG. 1A and FIG. 1B, which depicts a top plan view of system 100 (omitting computing device 112), reflector 100 is a parabolic reflector with predetermined depth “D” and focal length “F”. As illustrated by FIG. 1B, radiation generated by the antenna of assembly 108 is aligned by reflector 104. Incoming radiation is directed by reflector 104 towards the focal point, which is located along the axis of symmetry of reflector 104 at the distance F from the reflector’s vertex. Assembly 108 is therefore supported (via any suitable support structure, not shown) relative to reflector 104 so as to locate the antenna at the focal point of reflector 104.

[0021] The antenna has a beamwidth angle “A”, shown in FIG. 1B, indicating the angle at which the antenna is capable of emitting radiation or receiving radiation at or above a predefined level of the antenna’s maximum power or sensitivity (e.g. –10 dB relative to maximum). For example, the beamwidth angle A shown in FIG. 1B is about 100 degrees. Before discussing the features of the antenna that contribute to the beamwidth and other performance characteristics of the antenna, certain other components of assembly 108 will be described with reference to FIGS. 2A, 2B and 2C.

[0022] FIG. 2A illustrates a top view of assembly 108 (“top” as employed herein, refers to the direction facing reflector 104 when assembly 108 is installed as shown in FIGS. 1A and 1B). As seen in FIG. 2A, assembly 108 includes an assembly support member 200, which in the present embodiment includes a printed circuit board (PCB). Assembly support member 200 defines a mounting surface 204 thereon (specifically, on the upper side thereof, being the side configured to face reflector 104). Assembly support member 200 also includes a transmission electrical contact 208-t and a reception electrical contact 208-r. Mounting surface 204 is configured to receive an antenna assembly 212, as shown in FIG. 2B, and in doing so orient antenna assembly 212 to electrically connect contacts 208 with corresponding contacts on antenna assembly. Specifically, reception contact 208-r is connected with an output contact of antenna assembly 212, while transmission contact 208-t is connected with an input contact of antenna assembly 212. The contacts of antenna assembly 212 will be discussed further below.

[0023] The mechanism by which antenna assembly 212 is mounted to mounting surface 204 is not particularly limited. Mounting surface 204 includes any suitable surface-mount packaging, such as a ball grid array (BGA), to couple antenna assembly 212 to assembly support member 200 and place contacts 208-t and 208-r with the corresponding electrical contacts of antenna assembly 212.

[0024] FIG. 2C illustrates a bottom view (that is, a view of the side opposite from that shown in FIGS. 2A and 2B) of assembly 108. As seen in FIG. 2C, assembly 108 includes a radio processor 216 carried on assembly support member 200 (e.g. connected to assembly support member 200 via BGA or other surface mount structure). Radio processor 216

receives incoming signals from antenna assembly 212 and transmits the processed incoming signals to a baseband processor 220, also carried on assembly support member 200. Radio processor 216 and baseband processor 220, as will be apparent to those skilled in the art, each include one or more integrated circuits, and can be selected from any of a variety of conventional radio and baseband processors.

[0025] Radio processor 216 also receives outgoing signals from baseband processor 220 and applies the outgoing signals to antenna assembly 212 for transmission. Thus, radio processor 216 is electrically connected to electrical contacts 208 on the opposite side of assembly support member 200, by any suitable combination of vias and traces supported by assembly support member 200.

[0026] Baseband processor 220, in turn, is connected to a communications interface 224 carried by assembly support member 200. Communications interface 224 is any suitable communications interface, such as a Universal Serial Bus (USB) interface, an Ethernet interface or the like. Via communications interface 224, baseband processor 220 receives data from computing device 112 for transmission via radio processor 216 and antenna assembly 212. Baseband processor 220 also receives and processes incoming transmissions via antenna assembly 212 and radio processor 216, and transmits the incoming data to computing device 112 via communications interface 224.

[0027] Having described certain components of assembly 108, the features of antenna assembly 212 will now be described in greater detail. Referring to FIG. 3A, antenna assembly includes a support member 300 (such as a PCB). FIG. 3A illustrates a first side of support member 300 (which may also be referred to as the top or upper side, in that it faces reflector 104 when antenna assembly is installed) is depicted.

[0028] Supported on the first side of support member 300 are a plurality of patch antenna elements, which in the present embodiment are circular patches. In particular, a first phased array of transmission patch elements 304t, and a second phased array of reception patch elements 304r are supported on the first side of support member 300. The patch elements 304 may be etched from a layer of conductive material of support member 300, deposited as conductive material (e.g. copper, silver and the like) on support member 300, or manufactured by any other suitable process.

[0029] Each transmission patch element 304t is supported on support member 300 at a predefined distance from a central location on the first side of support member, labelled “PC” (the point PC does not necessarily have any particular structural feature, circuit element or the like). That is, the transmission patch elements 304t are disposed in a circular arrangement having PC as its center. Further, the transmission patch elements 304t are arranged such that the set of vectors extending from the point PC to respective transmission patch elements 304t sum to zero. That is, for the four transmission patch elements 304t shown in FIG. 3A, the four vectors extending from PC to those patch elements sum to zero. More specifically, in the present embodiment, this is achieved by placing the transmission patch elements 304t in symmetrical pairs about the point PC. Positioning the transmission patch elements 304t as described above places the phase center of the phased array of transmission patch elements 304t at the point PC.

[0030] Similarly, each reception patch element 304r is supported on support member 300 at a predefined distance

from the point PC. That is, the reception patch elements $304r$ are disposed in a circular arrangement having PC as its center. Further, the reception patch elements $304r$ are arranged such that the set of vectors extending from the point PC to respective reception patch elements $304r$ sum to zero. That is, for the four reception patch elements $304r$ shown in FIG. 3A, the four vectors extending from PC to those patch elements sum to zero. More specifically, in the present embodiment, this is achieved by placing the reception patch elements $304r$ in symmetrical pairs about the point PC. Positioning the reception patch elements $304r$ as described above places the phase center of the phased array of reception patch elements $304r$ at the point PC.

[0031] As will now be apparent from the above, the arrays of transmission and reception patch elements have a common phase center at the point PC as a result of their arrangements on support member 300. Various arrangements of the transmission and reception patch elements other than that shown in FIG. 3A are contemplated which achieve a common phase center for both transmission and reception. In the present embodiment, the predefined distance (i.e. the radius of the above-mentioned circular arrangements) is the same for both transmission patch elements $304t$ and reception patch elements $304r$. In addition, in the present embodiment the transmission and reception patch elements $304t$ and $304r$ are placed in an alternating arrangement on support member 300 (i.e. each transmission patch element $304t$ is placed between two reception patch elements $304r$).

[0032] Turning to FIG. 3B, a second side of support member 300 is illustrated, opposite the first side shown in FIG. 3A. That is, the side of support member 300 illustrated in FIG. 3B is referred to as the bottom or lower layer, due to its orientation away from reflector 104 when antenna assembly 212 is installed.

[0033] As seen in FIG. 3B, antenna assembly 212 includes an input electrical contact $308-i$ and an output electrical contact $308-o$. Input contact $308-i$ is connected to the first array of transmission patch elements $304t$, and transmission patch elements $304t$ are thus configured to receive an input signal via input contact $308-i$ and generate outbound radiation according to the input signal. As will now be apparent, the input signal is applied to input contact $308-i$ by radio processor 216 via transmission contact $208-t$.

[0034] Meanwhile, output contact $308-o$ is connected to the second array of reception patch elements $304r$, and reception patch elements $304r$ are thus configured to receive inbound radiation and generate an output signal at output contact $308-o$ according to the inbound radiation. As will now be apparent, the output signal generated at output contact $308-o$ is transmitted to radio processor 216 via reception contact $208-r$.

[0035] Antenna assembly 212, in some embodiments, includes additional structural features associated with the connections between contacts $308-i$ and $308-o$ and the corresponding arrays of patch elements. Turning to FIG. 4, antenna assembly 212 is illustrated with a substrate material (e.g. a dielectric material) of support member 300 omitted, revealing a plurality of conductive layers (e.g. of copper or silver). Each conductive layer includes various features, manufactured by etching, deposition, or the like. The spacing between conductive layers is exaggerated in FIG. 4 for illustrative purposes.

[0036] More specifically, in the present embodiment, support member 300 includes eight conductive layers 400-1, 400-2, 400-3, 400-4, 400-5, 400-6, 400-7 and 400-8. Layer 400-1 carries patch elements 304, as described above, while layer 400-8 carries contacts $308-i$ and $308-o$. The conductive layers between layer 400-1 and 400-8 carry various other features, to be discussed below.

[0037] A conductive layer 400 between the first and second sides of support member 300—layer 400-4, in the present embodiment, illustrated in FIG. 5—supports a first feed network 500 configured to interconnect the first array of transmission patch elements $304t$ with input electrical contact $308-i$. Contact $308-i$ and patch elements 304 are shown in FIG. 5 in dashed lines for illustrative purposes, but it will be understood that those elements are not present on layer 400-4.

[0038] Feed network 500 includes a primary feed line 504 travelling from a via connecting to input contact $308-i$ to a secondary feed line 508; secondary feed line 508 splits the signal from primary feed line 504 towards two terminal feed lines 512-1, 512-2, each of which further splits the signal between a pair of transmission patch elements $304t$ (terminal feed lines 512 are connected to intermediate patch elements, to be described in greater detail below, by additional vias). As also seen in FIG. 5, primary feed line 504 and secondary feed line 508 each include wider traces in regions approaching the downstream feed line. Thus, primary feed line 504 includes two successive increases in width as it approaches secondary feed line 508, and secondary feed line 508 includes two successive increases in width as it approaches terminal feed lines 512.

[0039] An additional conductive layer 400 between layer 400-4 (that is, the layer carrying first feed network 500) and layer 400-8—layer 400-6, in the present embodiment, illustrated in FIG. 6—supports a second feed network 600 configured to interconnect the second array of reception patch elements $304r$ with output electrical contact $308-o$. Contact $308-o$ and patch elements 304 are shown in FIG. 6 in dashed lines for illustrative purposes, but it will be understood that those elements are not present on layer 400-6.

[0040] Feed network 600 includes a primary feed line 604 travelling from a via connecting to input contact $308-o$ to a secondary feed line 608; secondary feed line 608 splits the signal from primary feed line 604 towards two terminal feed lines 612-1, 612-2, each of which further splits the signal between a pair of reception patch elements $304r$ (terminal feed lines 612 are connected to intermediate patch elements, to be described in greater detail below, by additional vias). As also seen in FIG. 6, primary feed line 604 and secondary feed line 608 each include wider traces in regions approaching the downstream feed line. Thus, primary feed line 604 includes two successive increases in width as it approaches secondary feed line 608, and secondary feed line 608 includes two successive increases in width as it approaches terminal feed lines 612.

[0041] In other embodiments, a wide variety of other feed network structures can be implemented, with different combinations of primary, secondary and terminal feed lines (as well as additional levels of feed lines if greater numbers of patch elements are employed). Further, the above-mentioned wider traces can be omitted in some embodiments. In addition, in other embodiments the elevation of feed net-

works **500** and **600** can be reversed (that is, feed network **500** can be placed closer to layer **400-8** than feed network **600**).

[0042] In addition to feed networks **500** and **600** being carried on different conductive layers **400**, support member **300** can include an additional conductive layer in between the layers carrying feed networks **500** and **600**, implemented as a ground plane. Thus, in the present embodiment, referring again to FIG. 4, layer **400-5** is a ground plane layer. An additional ground plane is also provided in the present embodiment, at layer **400-7** (i.e. between feed network **600** and layer **400-8**).

[0043] Further, in the present embodiment an additional conductive layer is provided between layer **400-1** (i.e. the layer supporting patch elements **304**) and layer **400-4** (i.e. the layer supporting feed network **500**). Turning to FIG. 7, layer **400-2** is illustrated in greater detail. Layer **400-2** carries a first plurality of intermediate patches **700_t**, configured to connect to feed network **500** and couple the electromagnetic energy from feed network **500** toward the array of transmission patch elements **304_t**. Layer **400-2** also carries a second plurality of intermediate patches **700_r**, configured to connect to feed network **600** and couple the electromagnetic energy from the array of reception patch elements **304_r** to feed network **600**. As will now be apparent, additional vias are provided to extend between the appropriate layers to connect feed networks **500** and **600** with intermediate patches **700_t** and **700_r**, respectively. No direct electrical connections are provided between intermediate patches **700** and patch elements **304**.

[0044] In other embodiments, the intermediate patches **700** can be omitted. When the intermediate patches **700** are omitted, direct electrical connections between feed networks **500** and **600** are patch elements **304** can be provided. In further embodiments, intermediate patches **700** have the same shape and size as patch elements **304**. In still further embodiments, a plurality of vertically-arranged intermediate patches are provided, with the bottom intermediate patch being electrically connected to the relevant feed network, and the remaining intermediate patches being electromagnetically coupled with each other and with the corresponding patch element **304**.

[0045] Returning to FIG. 4, layers **400-2** and **400-4** (that is, intermediate patch elements **700** and feed network **500**) can be separated by another ground plane at layer **400-3**. As will now be apparent to those skilled in the art, a variety of stack-up designs for support member **300** may be implemented to provide the antenna features set out above. Further, in some embodiments additional non-conductive material may be placed over layer **400-1**, to provide protection from the elements to patch elements **304**. For example, the protective coating may be implemented by placing an additional layer of substrate material (without any conductive material supported thereon) above layer **400-1**.

[0046] As noted earlier, layer **400-8** carries contacts **308-*i*** and **308-*o***, for example in signal pads. Support member **300** also includes a plurality of ground pads on layer **400-8**, not shown for simplicity of illustration. The ground pads, as well as associated vias, interconnect the ground planes (e.g. layers **400-3**, **400-5**, **400-7**) and connect to corresponding ground structures on assembly support member **108**.

[0047] Variations to the structure of antenna assembly **212** are contemplated. For example, in some embodiments the transmission patch elements **304_t** are placed at a different

predetermined distance from the point PC than the reception patch elements **304_r**. In further embodiments, the patch elements have non-circular shapes (e.g. rectangular shapes). In still further embodiments, a different number of transmission patch elements **304_t** is provided than of reception patch elements **304_r**.

[0048] In still further embodiments, the arrangement of the transmission and reception patches is other than in symmetrical pairs, and need not place the patches in the alternating arrangement shown in FIG. 3A. For example, FIGS. 8A, 8B and 8C depict additional variations of patch arrangements. FIG. 8A, in particular, depicts an antenna assembly **812** in which four transmission patch elements **804_t** and four reception patch elements **804_r** are provided. However, in contrast to the arrangement of FIG. 3A, transmission and reception patch elements **804** do not alternate, but instead are placed in adjacent pairs. FIG. 8B depicts another embodiment in which an antenna assembly **832** supports two transmission patch elements **834_t** and two reception patch elements **834_r** arranged as the corners of a square centered on the point PC. FIG. 8C depicts a further embodiment in which an antenna assembly **852** supports three transmission patch elements **854_t** and three reception patch elements **854_r** arranged as the vertices of equilateral triangles about the point PC.

[0049] Certain advantages to the antenna structures discussed above will now occur to those skilled in the art. For example, the implementation of arrays of patches for each of transmission and reception reduces or eliminates the need for switch mechanisms necessary in antennae with only one radiating element. Further, the placement of the above-mentioned arrays according to the teachings herein permits such arrays to be implemented with common phase centers suitable for use with reflectors. As a further example, the isolated feed networks for the transmission and reception arrays may reduce interference (e.g. mutual coupling between the transmission and reception feed networks), particularly in compact antenna assemblies that may be required to achieve required beamwidths (e.g. around 90 to 100 degrees of -10 dB beamwidth).

[0050] FIGS. 9A and 9B depict testing results for an example embodiment of a WiGig wireless communications assembly (i.e. based on the IEEE 802.11ad standard) as described above. The tested assembly employed a reflector with a depth of about 305 mm and a focal length of about 167 mm. An antenna assembly was employed having a support member with a length of 7.5 mm, a width of 6.5 mm, and a thickness of 0.949 mm and carrying arrays of transmission and reception patches as shown in FIG. 3A. The patches were electromagnetically coupled to feed networks structured as shown in FIGS. 5 and 6 by intermediate patches as shown in FIG. 7. The dimensions of the various features in the tested assembly were as shown in Table 1 below:

TABLE 1

Example Antenna Feature Dimensions	
Feature	Dimensions
Transmission/reception patches	820 μ m in diameter
Intermediate patches	100 μ m \times 300 μ m
Feed line (minimum width)	50 μ m in width
Feed line (intermediate width)	100 μ m

TABLE 1-continued

Example Antenna Feature Dimensions	
Feature	Dimensions
Feed line (greatest width)	155 μm
Vias	80 μm in diameter
Pads	100 μm in diameter
Input/Output contact pads	250 μm in diameter
Substrate	7.5 \times 6.5 mm
Substrate thickness	949 μm

[0051] FIG. 9A depicts the gain of the test antenna alone (i.e. without the reflector) at frequencies in the 60 GHz band, while FIG. 9B depicts the realized gain of the system at the broadside direction (i.e. the antenna acting as a feed for the reflector) at the same frequencies.

[0052] The scope of the claims should not be limited by the embodiments set forth in the above examples, but should be given the broadest interpretation consistent with the description as a whole.

1. An antenna assembly, comprising:
 - a support member having opposing first and second sides; an input electrical contact and an output electrical contact; a first array of transmission patch elements supported on the first side and connected to the input electrical contact, the first array configured to receive an input signal via the input electrical contact and generate outbound radiation according to the input signal; and a second array of reception patch elements supported on the first side and connected to the output electrical contact, the second array configured to receive inbound radiation and generate an output signal at the output electrical contact according to the inbound radiation; the first array and the second array having a common phase center.
2. The antenna assembly of claim 1, each transmission patch element of the first array being supported at a predefined distance from a central location on the first side; and each reception patch element of the second array being supported at the predefined distance from the central location on the first side
3. The antenna assembly of claim 2, the transmission patch elements supported in an alternating arrangement with the reception patch elements on the first side.
4. The antenna assembly of claim 3, the first array comprising four transmission patch elements, and the second array comprising four reception patch elements.
5. The antenna assembly of claim 1, each of the transmission patch elements and the reception patch elements being a circular patch element.
6. The antenna assembly of claim 1, further comprising: a protective coating applied over the first array and the second array.
7. The antenna assembly of claim 1, the input electrical contact and the output electrical contact being supported on the second side.
8. The antenna assembly of claim 7, further comprising: a first conductive layer of the support member between the first side and the second side, the first conductive

- layer supporting a first feed network configured to electromagnetically couple the first array and the input electrical contact.
- 9. The antenna assembly of claim 8, the first feed network comprising a feed line having a variable width.
- 10. The antenna assembly of claim 8, further comprising: a second conductive layer of the support member between the first conductive layer and the second side, the second conductive layer supporting a second feed network configured to electromagnetically couple the second array and the input electrical contact.
- 11. The antenna assembly of claim 10, the second feed network comprising a feed line having a variable width.
- 12. The antenna assembly of claim 10, the support member further having a ground plane disposed between the first conductive layer and the second conductive layer.
- 13. The antenna assembly of claim 10, the support member further having an intermediate conductive layer between the first side and the first conductive layer, the intermediate conductive layer supporting:
 - a first plurality of intermediate patches connected to the first feed network and configured to electromagnetically couple with the first array; and
 - a second plurality of intermediate patches connected to the second feed network and configured to electromagnetically couple with the second array.
- 14. A wireless communications assembly, comprising:
 - an assembly support member defining a mounting surface including a transmission electrical contact and a reception electrical contact;
 - a radio processor carried on the assembly support member and connected to the transmission electrical contact and a reception electrical contact; and
 - an antenna assembly according to claim 1, the support member coupled to the mounting surface to electrically connect the output electrical contact with the reception electrical contact and the input electrical contact with the transmission electrical contact.
- 15. The wireless communications assembly of claim 14, further comprising:
 - a baseband processor carried by the assembly support member and connected with the radio processor.
- 16. The wireless communications assembly of claim 15, further comprising:
 - a communications interface carried by the assembly support member and connected with the baseband processor, for connecting the baseband processor with a computing device.
- 17. A communications system, comprising:
 - a parabolic reflector having a focal point; and
 - a wireless communications assembly according to claim 16 supported to position the common phase center of the first array of transmission patch elements and the second array of reception patch elements at the focal point.
- 18. The communications system of claim 17, further comprising:
 - a computing device connected to the wireless communications assembly via the communications interface.

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