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(54) **ANTENNA COUPLING**

ANTENNENKOPPLUNG

COUPLAGE D'ANTENNE

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- **MAJID- FAKHERI ET AL: "A broad band circularly polarized cross slot cavity back array antenna with sequentially rotated feed network for improving gain in X-band application", INTERNATIONAL JOURNAL OF MICROWAVE AND WIRELESS TECHNOLOGIES20141014CAMBRIDGE UNIVERSITY PRESSGBR, vol. 9, no. 03, 23 May 2017 (2017-05-23), pages 705-710, XP055531451, ISSN: 1759-0787, DOI: 10.1017/S1759078716000532**

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Description

Field

[0001] Example embodiments relate to antenna coupling, for example an apparatus for coupling signals from one or more antennas for monitoring.

Background

[0002] Antenna systems, for example those which comprise an array of multiple antennas (or alternatively "antenna elements") may be used for beamforming, that is to produce a beam for directional transmission and/or reception. This may be achieved by combining antennas or antenna elements in such a way that signals at particular directions experience constructive or destructive interference. Beamforming enables spatial selectivity. Typically, in for example a multi-port antenna system, the phase and amplitude of a signal in each antenna port should be accurately known and controlled to steer the beam to wanted direction (and possibly) to control the side lobe level of the antenna array radiation pattern. In practise this means that the phase and amplitude of the signal should be monitored at multiple antenna ports.

[0003] Beamforming may be employed in cellular base stations that comprise a large number of antennas that communicate with multiple spatially separated user equipments (UEs) over the same frequency resource.

[0004] U.S. patent 2005/219123 describes a device for transmitting or emitting high-frequency waves, which includes: a microstrip line with one end in a substrate for transmitting high-frequency useful signals, a first ground surface and a second ground surface, which are provided on opposite sides of the microstrip line, for forming a TEM waveguide assembly. There is an opening in the first ground surface located at a predefined distance (d) from the end of the microstrip line for decoupling a high frequency signal. There is a feedthrough device for conductively connecting the first ground surface with the second ground surface on the lateral periphery of the microstrip line. There is a planar coupling device for receiving and transmitting or emitting the high-frequency useful signal. The feedthrough device is configured in such a way that at a given frequency (f) it prevents the propagation of waveguide modes and excitation of waveguide mode resonance in the useful frequency band (F).

[0005] EP0605338 describes a patch antenna, of the type comprising at least one radiating element generating two UHF waves with separate linear polarisations. The radiating element or elements are fed, on the one hand, through a first slot, by a first feed line, and, on the other hand, through a second and a third slot, by a second feed line, the second and third slots being of the same length (L2) and parallel to each other. Each radiating element resonates, on the one hand, along a first resonance axis perpendicular to the axis of the first slot and, on the other hand, along a second resonance axis perpendicular to the axis of the second and third slots, the intersection of these two resonance axes being at a right angle and defining a resonance centre. The first slot is centred transversely with respect to the said first resonance axis and longitudinally with respect to the said resonance centre. The second and third slots are centred transversely with respect to the said second resonance axis and placed at equal distances from the said resonance centre.

[0006] Prior art "A broad band circularly polarized cross slot cavity back array antenna with sequentially rotated feed network for improving gain in X-band application" by Majid-Fakheri et al. describes a broad band circularly polarized slot antenna array based on substrate-integrated waveguide (SIW) and aperture feeding techniques. The antenna element's impedance and 3 dB axial-ratio (AR) bandwidths are from 8.8 to 10.4 GHz (16.67%) and 9.5-10.7 GHz (12%), respectively. Employing an aperture-coupled feed and combining this method with a sequentially rotated network, a 2×2 antenna array is achieved. A parametric optimization procedure is used to enhance the antenna specifications. In the presented scheme by reducing mutual coupling caused by the SIW technique and sequentially rotated feed network, all parameters of the antenna are improved. Consequently, a novel antenna array with an impedance bandwidth of 2.8 GHz (8.7-11.5 GHz) and a 3 dB AR bandwidth of 2.1 GHz (9-11.05 GHz) are obtained. The average gain of the proposed antenna is about 16.7 dBic. A new method is used to increase the gain of the antenna array. The extracted result shows that the side lobe level, mutual coupling, impedance bandwidth, and performance of the antenna are simultaneously controlled. U.S. patent 2003/227420 describes an integrated aperture and calibration feed network for adaptive beam forming systems.

Summary

[0007] A first aspect provides an apparatus comprising: an antenna feed for directing RF signals to and/or from an antenna; coupling means for coupling a signal from a radiating portion of an antenna for dynamic monitoring and/or calibration, the antenna comprising one or more antenna elements and a ground plane, the coupling means comprising: an aperture which passes through the ground plane of the antenna; and a conductor for coupling a signal carried by the one or more antenna elements, part of the conductor extending over at least part of the aperture, wherein the coupling means is for coupling signals from respective radiating portions of a plurality of such antennas, the coupling means comprising a plurality of such apertures spaced apart from the one or more antenna elements, and the conductor is arranged such that respective parts of the conductor extend over at least part of each aperture, and wherein the plurality of antennas are arranged as an array comprising one or more rows of antennas, and wherein the conductor extends from a first terminal (C1) of a connecting port to each of the apertures, and wherein the connecting port is configured for connection to measurement and/or calibration equipment and/or to at least one of a transceiver, transmitter and/or receiver circuitry.

[0008] The aperture may be a slot.

[0009] The aperture may be positioned substantially opposite the one or more antenna elements.

[0010] The part of the conductor that extends over a part of the aperture may have a greater width relative to another part of the conductor which does not extend over part of the aperture. Said width of the part of the conductor that extends over part of the aperture may be tuned to compensate for impedance caused by the slot.

[0011] The aperture may be provided within the ground plane of a dual polarised antenna.

[0012] The antenna may comprise a plurality of dipole antenna elements on a reflector ground plane, the aperture being provided in the reflector ground plane.

[0013] The one or more antenna elements of the antenna may comprise one or more slotted resonant antenna elements, and a conductive antenna cavity defined at least partly by a wall to one side of the one or more antenna elements, the aperture being provided in the cavity wall.

[0014] The conductor may be spaced from the ground plane either by a dielectric material or air.

[0015] The coupling means may be for coupling signals from respective radiating portions of a plurality of such antennas, the coupling means comprising a plurality of such apertures spaced apart from the one or more radiating elements, and the conductor is arranged such that respective parts of the conductor extend over at least part of each aperture.

[0016] The plurality of antennas may be arranged as an array comprising one or more rows of antennas, and wherein the conductor extends from a first terminal of a connecting port for signal measurement equipment, between the two or more spaced-apart rows, to each of the apertures in series, and returns to a second terminal of the connecting port.

[0017] The conductor may be provided as a track on substantially one side only of a printed wire board or similar substrate.

[0018] Another aspect provides an antenna array or a base station comprising an apparatus as claimed in any preceding definition. The antenna array or base station may further comprise measurement and calibration means for receiving the coupled signals, and for measuring and calibrating the amplitude and/or phase of signals respectively received from, and/or provided to, the antennas. The calibration means may be configured to modify one or more signals provided to the antennas to substantially maintain a required beam profile.

Drawings

[0019] Embodiments will now be described by way of non-limiting example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of a measurement and calibration system, useful for understanding example embodiments;

Figure 2A is a perspective view of an antenna and coupling structure in accordance with example embodiments;

Figure 2B is a perspective view of an antenna array comprising multiple Figure 2A antennas in accordance with example embodiments;

Figure 2C is a close-up view of a coupler on a reverse side of the Figure 2A antenna in accordance with example embodiments;

Figure 3 is a perspective view of the Figure 2C coupler and associated conductive coupler line in accordance with example embodiments;

Figure 4 is a perspective view of the Figure 2C coupler and another conductive coupler line in accordance with example embodiments;

Figure 5A is a plan view of a printed circuit board on which a serial conductive coupler line is provided in accordance with example embodiments;

Figure 5B is a plan view of a printed circuit board on which a single conductive coupler line r is provided in accordance with example embodiments;

Figure 6A is a perspective view of an antenna and coupling structure in accordance with other example embodiments; and

Figure 6B is a plan view of an array of Figure 6A antennas and a coupling structure in accordance with other example embodiments.

Detailed Description

[0020] Example embodiments relate to antenna coupling, for example an apparatus or structure for coupling a signal from one or more antennas, for example from a plurality of antennas forming an array for beamforming purposes in use. Example embodiments may relate to a coupling apparatus for an antenna array provided on a cellular base station, with associated monitoring and/or calibration equipment or circuitry which may receive signals from transmission lines associated with the coupler for analysis or processing. Other applications are however within the scope of the following.

[0021] Antenna systems, for example those which comprise an array of multiple antennas (or alternatively "antenna elements" or "radiating elements") may be used to produce a beam for directional transmission and/or reception. This may be achieved by combining antennas or antenna elements in such a way that signals at particular directions experience constructive or destructive interference. This "beamforming" may be employed in, for example, cellular base stations that comprise a large number of antennas that communicate with multiple spatially separated user equipments (UEs) over the same frequency resource.

[0022] Consequently, it is known to use equipment to receive signals coupled from one or more antennas for measuring the phase and amplitude of signals from the one or more antenna elements, and if required, to modify and/or calibrate the phase and amplitudes using non-radiative control to achieve required or desired beam form characteristics. This may be known as dynamic monitoring and/or calibration, and is useful for continuous monitoring and/or calibration over extended time periods. Monitoring at least is useful for understanding the array status for network management purposes.

[0023] Example embodiments relate to improvements in signal coupling. A coupler is a point or structure provided with an antenna or antenna array for receiving an indication of the antenna's signals. In some embodiments, a coupler comprises both an aperture in a ground plane and a coupling or transmission line conductor. These coupled signals are effectively 'sniffed' by the coupler at a low signal level, in a process generally referred to herein as coupling, and these low signal levels are sent back to the monitoring and/or calibration equipment, which determines amplitude and phase information for comparison with signals sniffed by one or more other couplers associated with respective one or more other antennas. If needed, calibration equipment can adjust the amplitude and/or phase to one or more antennas. The coupler may be directional.

[0024] Example embodiments may reduce complexity and hardware implementation costs for coupling signals from the antenna elements for provision to, for example, the monitoring and/or calibration equipment, which may be remote from the antenna elements, e.g. at the bottom of a radio tower. In general, every hardware difference the signal encounters before reaching the antenna element, after the measurement point, may add error to the phase and amplitude difference between the signals and thus may lead to worse signal performance in terms of lower gain, incorrect steering angle and/or higher side lobes.

[0025] Further, the more antenna elements present, the more complex the transmission lines from the couplers to the monitoring apparatus. In the case of Multiple Input Multiple Output (MIMO) systems, for example massive MIMO (mMIMO) systems, the minimum number of antenna inputs is sixteen, which may result in a long and complex network of couplers and associated transmission lines. This may introduce additional errors and hence worsen the original system performance. Embodiments herein may provide advantages in this regard.

[0026] Figure 1 is a schematic view of a monitoring and calibration system 10, useful for understanding the context of example embodiments. An antenna system 20 comprising an array of N antennas 30, which may be multi-port antennas, is provided. The antennas 30 may be of any suitable type, and in embodiments below we assume they are cavity-backed slot antennas. Any number of antennas 30 may comprise the antenna system array. Each antenna 30 has at least one coupler 40 positioned in proximity, sufficient to 'sniff' signals transmitted and/or received by a respective antenna in response to a radio frequency signal applied to the antenna. This sniffing may direct a very small signal in comparison to the transmitted signal, e.g. a - 20dB level, to the monitoring and calibration system 10. The signal received at each coupler 40 may provide an attenuated and phase shifted version of the respective antenna signal; these are connected through a network of transmission lines 50 to a radio frequency (RF) switch 60 which compares the current coupled signal with a reference signal to produce a direct current (DC) output corresponding to the phase and amplitude difference, by means of an analogue to digital converter (ADC) 70. A computer system 80 may receive and process the phase and amplitude differences, if detected, and produce a signal for transmission to respective adjustment modules 90 via a digital to analogue converter (DAC) 100. In the shown example, one adjustment module 90 for each antenna 30 is provided, to allow control of the phase and amplitude of the RF signal of respective antennas to be varied with respect to the input by applying a DC voltage to phase and amplitude control inputs of each antenna.

[0027] It should be emphasised that Figure 1 is merely for reference. The practical realisation of the indicated transmission line network 50 for an antenna system 20 having a large number of antennas 30 (e.g. in a mMIMO system) is challenging to provide, e.g. as a single plane on a printed circuit board (PCB) or the like, without adding further errors to phase and amplitude differences.

[0028] Figure 2A shows in exploded view an example antenna 110 which incorporates a coupler 120 in accordance with an example embodiment. The coupler 120 may be a near-field coupler, as the proximity is such at the operating frequency that the coupler is in the near-field of the antenna.

[0029] The antenna 110 is of the type known in the art as a cavity-backed slot antenna, and comprises a cavity 130 defined by a base wall 150 with (in this example) four upstanding walls 160 to provide a box-like structure. Any suitable arrangement or shape may be employed, as will be appreciated, and any suitable number of walls may be used so long as a hollow cavity is provided. The material forming the cavity 130 may be an electrically conductive material such as metal material. The cavity 130 may be mounted on a ground plane. For example, the box-like structure may be connected to a grounded element such as a conductive sheet on a printed wire board (PWB) or a conductive sheet of metal or the like that provides an antenna ground plane. The box-like structure, being conductive, may provide the whole ground plane or part of an overall ground plane provided by the box-like structure and one or more other conductive members. Any part of a radio tower or mast for an antenna array, for example, may provide grounded metal members which may form part of an overall ground plane. In addition, other boxes or housings used to house radio communications circuitry, for example transceivers, transmitters, receiver components and circuitry, baseband circuitry, control circuitry, routing circuitry and/or switching circuitry may provide at least part of a ground plane, including any ground layers that may cover all or part of a complete layer of a PWB.

[0030] A radiating element 170 is provided in the form of a metal plate, which may or may not be integral with the box-like structure defining the cavity 130. Within the radiating element 170 is or are formed one or more slotted resonant elements 180; in this example, these may be provided by two slots 180 in different orientations but providing a single cross-shaped aperture, formed in the manner of an "X" shape. The two slots 180 may therefore intersect. In this arrangement, the different slots 180 produce different polarisations by virtue of their respective orientations. The different polarisations maybe substantially orthogonal.

[0031] The radiating element 170 of the antenna 110 may employ any arrangement of one or more slots 180. In other embodiments, the slots 180 may have other shapes or sizes. For example, there may be provided a single polarisation slot, which may be rectangular. For example, there may be multiple such slots. In other embodiments, there may be elliptically polarised antenna elements. Embodiments are not limited to any particular form of antenna or polarisation.

[0032] The radiating element 170 may be located in use on the upper wall 190 of the resonant metal cavity 130, defined by the upper surfaces of the upstanding walls 160, or may be located elsewhere such that the resonant cavity 130 is one side thereof.

[0033] A metal probe (not shown) provides a RF signal to cause excitation of the antenna 110, the result being that the cavity 130 acts as a waveguide and the slots 180 radiate electromagnetic waves according to their shape and size, as well as the frequency of the RF drive signal. The probe maybe a coaxial probe in some embodiments. When the antenna array elements receive electromagnetic RF signals from another electronic device (for example, a mobile telephone or smartphone) via the ether or free-space, the probe acts as an antenna feed and directs the received RF signals to the radio frequency circuitry (transceiver/receiver). Consequently, when the radio frequency circuitry (transceiver/transmitter) generates RF signals for transmission via the antenna array elements, the probe acts as an antenna feed and directs the RF signals generated by the RF circuitry to the antenna array elements for propagation into the ether for reception by one or more separate electronic devices.

[0034] Multiple instances of the antenna 110 may be provided as separate individual modules, for example multiple cavities 130 and multiple radiating elements 170. Alternatively, the multiple instances may be provided by a single contiguous piece of conductive material having multiple cavities 130, with either individual radiating elements 170 or a single plate having multiple sets of slots 180 which overlie respective ones of the cavities. The multiple antennas 110 may be located substantially on a single plane.

[0035] In this manner, an antenna array may be provided, for example as part of a MIMO or mMIMO system. Figure 2B shows an example array formed of multiple such antennas 100 on a substantially single plane. The single plane may be a curved plane in one or more directions in some embodiments.

[0036] Referring now to Figure 2C, in accordance with some example embodiments, a coupler for coupling signals produced by the or each antenna 110 is an aperture 120 which passes through a wall, for example the base wall 150, of the cavity 130. The aperture 120 may be elongate, e.g. in the manner of a substantially rectangular slot. The aperture 120 is dimensionally smaller than the radiating elements 170. The aperture 120 enables coupling of, in this case, both polarizations of the slotted resonant elements 180 using only one simple coupling structure rather than two couplers for each polarization. In some embodiments, the aperture 120 is placed substantially opposite the intersection point of the slotted resonant elements 180

[0037] A slot is defined herein as a closed slot or hole in a conductive member. The slot does not have any open ends and is completely surrounded by conductive material. A slot as mentioned herein may be rectangular, or in some cases may be another shape, for example L-shaped. It may be relatively small so as not to impact antenna performance. For example, it may be in the region of 0.1λ.

[0038] On the opposite side of the base wall 150 is provided part of a conductor 200, hereafter "conductive coupler line" for carrying coupled signals to electronic devices.

[0039] Referring to Figure 3, part of the base wall 150 opposite side is shown. The conductive coupler line 200 may comprise a strip of conductive material printed or otherwise provided on a substrate, e.g. a PWB, a first side of which may be attached to the underside of the base wall 150. The conductive coupler line 200 may be carried by a second, opposite side of the PWB such that the PWB material is between the strip of conductive material and the base wall. The conductive coupler line 200 may be, for example a 50 ohm transmission microstrip line. The PWB or other substrate may comprise a dielectric material such as FR-4, or other RF or microwave substrate or laminate, including ceramics such as alumina, composites etc. In some embodiments, the conductive coupler line 200 may be suspended above or below the base wall 150 by a plurality of spaced-apart supports, leaving an air gap between the strip and the base wall and therefore not requiring a PWB. The conductive coupler line 200 may be relatively low profile and may extend along the base wall 150 in a single plane. In some embodiments, the conductive coupler line 200, at some parts along its length, may change planes or layers, and/or curve around walls or other obstacles. Changes in planes or layers may be achieved using vias. At least part of the conductive coupler line 200 extends up to, and partially over, the aperture 120 and is found in this arrangement to sufficiently receive coupled signals of both polarizations from the radiating elements 170.

[0040] Where two or more antennas 110 are provided on the same plane, such as in the manner of Figure 2B, the conductive coupler line 200 may continue over the aperture 120 to the next adjacent aperture 120 as indicated by the dotted lines in Figure 3. It will be appreciated therefore that the conductive coupler line 200 has a relatively simple structure in a single plane for coupling of multiple antennas 110 with little or no bends or turns that may add distortions. Any number of adjacent antennas 110 may be coupled and signals fed therefrom in this arrangement. In some embodiment, a single conductive coupler line 200 may couple all antenna elements of an array, rather than having separate coupler lines for each and every antenna element of the array.

[0041] Referring to Figure 4, in some embodiments, part of the conductive coupler line 200 that overlies the one or more apertures 120 may have a different shape or profile than the remainder of the conductor. In this case, the conductive coupler line 200 has a wider portion 220 which is found to compensate for the impedance impact of the slot. The appropriate width, shape or profile may be determined using routine experimentation. As before, where two or more antennas 110 are provided on the same plane, such as in the manner of Figure 2B, the conductive coupler line 200 may continue over the aperture 120 to the next adjacent aperture 120 as indicated by the dotted lines in Figure 4.

[0042] The material of the conductive coupler line 200 may be copper, e.g. in the form of thin copper sheet or copper tape, and may be deposited on the base wall 150 using any appropriate method, such as by means of a PWB or using supports formed of a low-loss dielectric material.

[0043] In consequence of the described coupler and conductive coupler line 200 the arrangement of the conductive coupler line over a single plane can be simplified to avoid errors introduced by mechanical features.

[0044] Figure 5A shows in plan-view one side of a printed circuit board (PCB) 240 or the like, on which may be mounted an array of antennas 110 (not shown in the Figure) for example in a MIMO or mMIMO array or any other kind of array. The conductive coupler line 200 partly shown in Figures 3 and 4 is indicated as a serial path to first and second connection points C1, C2 which connect to measurement and/or calibration equipment 300 and/or may lead off to transceiver, transmitter and/or receiver circuitry if integrated within the same PCB/PWB or a separate PCB/PWB. The simplicity of the conductive coupler line 200 arrangement is evident.

[0045] Figure 5B shows in plan-view one side of a printed circuit board (PCB) 250 or the like, on which may be mounted an array of antennas 110 (not shown in the Figure) for example in a MIMO or mMIMO array or any other kind of array. A differently-arranged conductive coupler line 260, being a single direction coupling path, extends to a first connection point C1 which may similarly connect to measurement and/or calibration equipment 300 as in Figure 5A and/or may lead off to transceiver, transmitter and/or receiver circuitry if integrated within the same PCB/PWB or a separate PCB/PWB. Otherwise, the manner in which the conductive coupler line 260 is arranged on a single plane on the PCB 250 and partly overlies the apertures 120 for receiving and passing the coupled signals is the same.

[0046] Similar to Figure 5A, the simplicity of the conductive coupler line 200 arrangement is evident.

[0047] As mentioned above, the coupling apparatus is not limited to any particular form of antenna or polarisation. For example, the coupling apparatus is applicable to single antenna elements, e.g. a circularly or elliptically polarised antenna element, having a coupling slot. For example, one or more dual polarised antennas may be provided on a ground plane with an aperture. For example, an arrangement of two or more dipoles providing dual polarisation may be provided on a ground plane acting as a reflector. Referring to Figure 6A, for example, another embodiment provides first and second dipoles 315, 320 in a crossing arrangement, mounted to a ground plane reflector 322. The dotted lines in this case are merely to indicate the different dipoles. A slot or aperture 325 is formed in the ground plane reflector 322 as shown, and a conductive coupler line provided on the underside of said ground plane reflector in the manner already described. Figure 6B shows how multiple such dual dipoles 350 in any array formation may be provided on a common ground plane reflector 352, with multiple slots 325 formed therein. As will be seen, each slot 325 may couple signals from two or more such dual dipoles 350. One or more conductive coupler lines 330 may be provided on the underside in the manner already described.

[0048] The above-described embodiments may be applicable to radio towers or masts, for example associated with a radio base station, e.g. a 3G, 4G, 5G or future radio communication systems. Such towers, masts or base stations may have at least one of a receiver, a transmitter and a transceiver. The towers, masts or base stations may also comprise one or more of control circuitry, routing and switching circuitry.

[0049] As used herein, a PWB can be any form of printed wiring board, including printed circuit boards, flexi circuits, semi-flexible circuits and other forms of printable substrates and laminates.

[0050] In overview, example embodiments relate to one or more couplers for coupling signals from one or more respective antennas and to a conductive coupler line arrangement. The conductive coupler line arrangement is also relatively simple to produce and introduces little or no discontinuities that may otherwise add errors to the signals being monitored.

[0051] The location of the one or more couplers in the antenna radiation part means that one coupler can be used for more than one antenna input and more than one antenna port. The couplers and conductive coupler line may be formed in the manner of a microstrip transmission line. Other forms of transmission line other than microstrip, may also be used to form, part or all of the couplers, and part or all of the conductive coupler line, such as, and not limited to: stripline, coplanar waveguide (CPW), slotline, coplanar strips, microwave waveguide, and coaxial cable. In an embodiment where the transmission line is a closed-form of transmission line, the signal conductor(s) is(are) surrounded by a ground layer or sheathing, for example a coaxial cable or stripline. In this case one or more local opening in the ground layer or sheathing of the transmission line is disposed adjacent the aperture or slot 120, 325 so that the transmission line is configured to couple signals from the antenna 110, 315, 320.

[0052] While the forgoing examples are illustrative of the principles of the present invention in one or more particular applications, it will be apparent to those of ordinary skill in the art that numerous modifications in form, usage and details of implementation can be made without the exercise of inventive faculty, and without departing from the invention. Accordingly, it is not intended that the invention be limited, except as by the claims set forth below.

Claims

1. Apparatus (10) comprising:

an antenna feed for directing RF signals to and/or from an antenna (30, 110, 315, 320, 350); and

coupling means configured to couple a signal from a radiating portion of the antenna (30, 110, 315, 320, 350) and configured to dynamically monitor and/or calibrate the antenna (30, 110, 315, 320, 350), the antenna (30, 110, 315, 320, 350) comprising one or more antenna elements (170) and a ground plane,

the coupling means comprising:

the ground plane of the antenna; an aperture (120, 325) which passes through the ground plane of the antenna (30, 110, 350); and

a conductor (200, 260, 330) for coupling a signal carried by the one or more antenna elements (170), part of the conductor (200, 260, 330) extending over at least part of the aperture (120, 325),

wherein the coupling means is further configured to couple signals from respective radiating portions of a plurality of such antennas (30, 110, 315, 320, 350),

the coupling means further comprising a plurality of such apertures (120, 325) spaced apart from the one or more antenna elements (170) of the plurality of antennas, and wherein

the conductor (200, 260, 330) is arranged such that respective parts of the conductor (200, 260, 330) extend over at least part of each aperture (120, 325), and

wherein the plurality of antennas (30, 110, 315, 320, 350) are arranged as an array comprising one or more rows of antennas (30, 110, 315, 320, 350), and

wherein the conductor (200, 260, 330) extends from a first terminal (C1) of a connecting port to each of the apertures (120, 325), and

wherein the connecting port is configured for connection to measurement and/or calibration equipment (300) and/or to lead off to a transceiver, transmitter and/or receiver circuitry.

2. The apparatus of claim 1, wherein the aperture is a slot.

3. The apparatus of claim 1 or claim 2, wherein the aperture is positioned substantially opposite the one or more antenna elements.

4. The apparatus of any preceding claim, wherein the part of the conductor that extends over a part of the aperture has a greater width relative to another part of the conductor which does not extend over part of the aperture.

5. The apparatus of claim 4, wherein said width of the part of the conductor that extends over part of the aperture is tuned to compensate for impedance caused by the slot.

6. The apparatus of any preceding claim, wherein the aperture is provided within the ground plane of a dual polarised antenna.

7. The apparatus of claim 6, wherein the antenna comprises a plurality of dipole antenna elements on a reflector ground plane, the aperture being provided in the reflector ground plane.

8. The apparatus of any of claims 1 to 6, wherein the one or more antenna elements of the antenna comprise one or more slotted resonant antenna elements, and a conductive antenna cavity defined at least partly by a wall to one side of the one or more antenna elements, the aperture being provided in the cavity wall.

9. The apparatus of any preceding claim, wherein the conductor is spaced from the ground plane either by a dielectric material or air.

10. The apparatus of any preceding claim, wherein part or all of the coupling means are configured to form a transmission line.

11. The apparatus of claim 10, wherein the transmission line is at least one of a microstrip line, a stripline, a co-planar waveguide, a slotline, coplanar strips, a waveguide and a coaxial cable.

12. The apparatus of any preceding claim, wherein the conductor is provided as a track on substantially one side only of a printed wire board or similar substrate.

13. An antenna array or a base station comprising an apparatus as claimed in any of claims 1 to 12.

14. The antenna array or base station of claim 13, further comprising measurement and calibration means for receiving the coupled signals, and for measuring and calibrating the amplitude and/or phase of signals respectively received from, and/or provided to, the antennas.

15. The antenna array or base station of claim 14, wherein the calibration means is configured to modify one or more signals provided to the antennas to substantially maintain a required beam profile.

Patentansprüche

1. Vorrichtung (10) mit:

einer Antennenzuleitung zum Führen von HF-Signalen zu und/oder von einer Antenne (30, 110, 315, 320, 350); und
Kopplungsmitteln, die so konfiguriert sind, dass ein Signal von einem Strahlungsanteil der Antenne (30, 110, 315, 320, 350) gekoppelt wird, und so konfiguriert sind, dass die Antenne (30, 110, 315, 320, 350) dynamisch überwacht und/oder kalibriert wird, wobei die Antenne (30, 110, 315, 320, 350) eine oder mehrere Antennenelemente (170) und eine Grundplatte aufweist,
wobei die Kopplungsmittel umfassen:

die Grundplatte der Antenne; eine Apertur (120, 325), die durch die Grundplatte der Antenne (30, 110, 350) führt; und
einen Leiter (200, 260, 330) zum Koppeln eines Signals, das durch ein oder mehrere Antennenelemente (170) übertragen wird, wobei ein Teil des Leiters (200, 260, 330) über mindestens einen Teil der Apertur (120, 325) verlängert wird,

wobei die Kopplungsmittel weiter so konfiguriert sind, dass Signale von den jeweiligen Strahlungsanteilen einer Vielzahl dieser Antennen (30, 110, 315, 320, 350) gekoppelt werden,
wobei die Kopplungsmittel weiter eine Vielzahl dieser Aperturen (120, 325) aufweisen, die räumlich getrennt von einem oder mehreren Antennenelementen (170) der Vielzahl von Antennen angeordnet sind,
und
wobei der Leiter (200, 260, 330) so angeordnet ist, dass die jeweiligen Teile des Leiters (200, 260, 330) über mindestens einen Teil jeder Apertur (120, 325) verlängert werden, und
wobei die Vielzahl von Antennen (30, 110, 315, 320, 350) als Array angeordnet sind, das eine oder mehrere Reihen von Antennen (30, 110, 315, 320, 350) aufweist, und
wobei der Leiter (200, 260, 330) von einem ersten Terminal (C1) eines Anschlussports zu jeder Apertur (120, 325) verlängert wird, und
wobei der Anschlussport so konfiguriert ist, dass er mit einer Mess- und/oder Kalibriervorrichtung (300) verbunden und/oder zu einem Sendeempfänger-, Sender- und/oder Empfängerschaltkreis abgeleitet wird.

2. Die Vorrichtung nach Anspruch 1, wobei die Apertur ein Schlitz ist.

3. Die Vorrichtung nach Anspruch 1 oder 2, wobei die Apertur im Wesentlichen gegenüber von einem oder mehreren Antennenelementen angeordnet ist.

4. Die Vorrichtung nach einem der vorstehenden Ansprüche, wobei der Teil des Leiters, der über einen Teil der Apertur verlängert wird, eine größere Breite gegenüber dem anderen Teil des Leiters aufweist, der nicht über einen Teil der Apertur verlängert wird.

5. Die Vorrichtung nach Anspruch 4, wobei dieser Breite des Teils des Leiters, der über einen Teil der Apertur verlängert wird, angepasst wird, um die durch den Schlitz verursachte Impedanz auszugleichen.

6. Die Vorrichtung nach einem der vorstehenden Ansprüche, wobei die Apertur in der Grundplatte einer dual-polarisierten Antenne bereitgestellt wird.

7. Die Vorrichtung nach Anspruch 6, wobei die Antenne eine Vielzahl von Dipolantennenelementen auf einer Reflektor-Grundplatte aufweist, wobei die Apertur in der Reflektor-Grundplatte bereitgestellt wird.

8. Die Vorrichtung nach einem der Ansprüche 1 bis 6, wobei ein oder mehrere Antennenelemente der Antenne ein oder mehrere geschlitzte Resonanzantennenelemente aufweisen, und ein leitender Antennenhohlraum mindestens teilweise durch eine Wand an einer Seite eines oder mehrerer Antennenelemente definiert ist, wobei die Apertur in der Hohlraumwand bereitgestellt wird.

9. Die Vorrichtung nach einem der vorstehenden Ansprüche, wobei der Leiter entweder durch ein dielektrisches Material oder Luft räumlich getrennt von der Grundplatte angeordnet ist.

10. Die Vorrichtung nach einem der vorstehenden Ansprüche, wobei die Kopplungsmittel teilweise oder vollständig so konfiguriert sind, dass sie eine Übertragungsleitung bilden.

11. Die Vorrichtung nach Anspruch 10, wobei die Übertragungsleitung mindestens eine Mikrostreifenleitung, eine Streifenleitung, ein koplanarer Wellenleiter, eine Schlitzleitung, koplanare Streifen, ein Wellenleiter oder ein Koaxialkabel ist.

12. Die Vorrichtung nach einem der vorstehenden Ansprüche, wobei der Leiter als Bahn im Wesentlichen nur auf einer Seite einer Leiterplatte oder eines ähnlichen Substrats bereitgestellt wird.

13. Ein Antennenarray oder eine Basisstation mit einer Vorrichtung nach einem der Ansprüche 1 bis 12.

14. Das Antennenarray oder die Basisstation nach Anspruch 13, das oder die weiter Mess- und Kalibriermittel zum Empfangen von Koppelsignalen und zum Messen und Kalibrieren der Amplitude und/oder der Phase von Signalen aufweist, die jeweils von Antennen erhalten und/oder zu den Antennen geleitet werden.

15. Das Antennenarray oder die Basisstation nach Anspruch 14, wobei die Kalibriermittel so konfiguriert sind, dass ein oder mehrere Signale geändert werden, die zu den Antennen geleitet werden, um ein erforderliches Strahlprofil im Wesentlichen aufrechtzuerhalten.

Revendications

1. Appareil (10) qui comprend :

une alimentation d'antenne pour diriger des signaux RF vers et/ou depuis une antenne (30, 110, 315, 320, 350) ; et
un moyen de couplage configuré pour coupler un signal depuis une partie de rayonnement de l'antenne (30, 110, 315, 320, 350) et configuré pour piloter et/ou étalonner de façon dynamique l'antenne (30, 110, 315, 320, 350), l'antenne (30, 110, 315, 320, 350) comprenant un ou plusieurs éléments d'antenne (170) et un tapis de sol,
le moyen de couplage comprenant :

le tapis de sol de l'antenne ; un orifice (120, 325) qui passe à travers le tapis de sol de l'antenne (30, 110, 350) ; et
un conducteur (200, 260, 330) pour coupler un signal acheminé par les un ou plusieurs éléments d'antenne (170), une partie du conducteur (200, 260, 330) s'étendant par-dessus au moins une partie de l'orifice (120, 325),

dans lequel le moyen de couplage est en outre configuré pour coupler des signaux de parties de rayonnement respectives d'une pluralité de telles antennes (30, 110, 315, 320, 350),
le moyen de couplage comprenant en outre une pluralité de tels orifices (120, 325) espacés des un ou plusieurs éléments d'antenne (170) de la pluralité d'antennes, et dans lequel
le conducteur (200, 260, 330) est agencé de telle sorte que les parties respectives du conducteur (200, 260, 330) s'étendent par-dessus au moins une partie de chaque orifice (120, 325), et
dans lequel la pluralité d'antennes (30, 110, 315, 320, 350) sont agencées en tant que réseau qui comprend une ou plusieurs rangées d'antennes (30, 110, 315, 320, 350), et
dans lequel le conducteur (200, 260, 330) s'étend depuis une première borne (C1) d'un port de liaison vers chacun des orifices (120, 325), et
dans lequel le port de liaison est configuré pour relier à un équipement de mesure et/ou d'étalonnage (300) et/ou pour conduire vers une circuiterie d'émetteur-récepteur, d'émetteur et/ou de récepteur.

2. Appareil selon la revendication 1, dans lequel l'orifice est une fente.

3. Appareil selon la revendication 1 ou la revendication 2, dans lequel l'orifice est positionné essentiellement à l'opposé des un ou plusieurs éléments d'antenne.

4. Appareil selon l'une quelconque des revendications précédentes, dans lequel la partie du conducteur qui s'étend par-dessus une partie de l'orifice présente une largeur supérieure à celle d'une autre partie du conducteur qui ne s'étend pas par-dessus une partie de l'orifice.

5. Appareil selon la revendication 4, dans lequel ladite largeur de la partie du conducteur qui s'étend par-dessus une partie de l'orifice est réglée pour compenser une impédance causée par la fente.

6. Appareil selon l'une quelconque des revendications précédentes, dans lequel l'orifice est prévu à l'intérieur du tapis de sol d'une antenne bipolarisée.

7. Appareil selon la revendication 6, dans lequel l'an-

tenne comprend une pluralité d'éléments d'antenne doublet sur un tapis de sol de réflecteur, l'orifice étant prévu dans le tapis de sol de réflecteur.

8. Appareil selon l'une quelconque des revendications 1 à 6, dans lequel les un ou plusieurs éléments d'antenne de l'antenne comprennent un ou plusieurs éléments d'antenne résonnante à fente et une cavité d'antenne conductrice définie au moins partiellement par une paroi sur un côté des un ou plusieurs éléments d'antenne, l'orifice étant prévu dans la paroi de cavité.

9. Appareil selon l'une quelconque des revendications précédentes, dans lequel le conducteur est espacé du tapis de sol soit par un matériau diélectrique soit par de l'air.

10. Appareil selon l'une quelconque des revendications précédentes, dans lequel tout ou partie des moyens de couplage sont configurés pour former une ligne de transmission.

11. Appareil selon la revendication 10, dans lequel la ligne de transmission est au moins l'un parmi une ligne microruban, une ligne à ruban, un guide d'ondes coplanaire, une ligne à fente, des rubans coplanaires, un guide d'ondes et un câble coaxial.

12. Appareil selon l'une quelconque des revendications précédentes, dans lequel le conducteur est prévu en tant que piste sur essentiellement un côté uniquement d'une carte de circuit imprimé ou d'un substrat analogue.

13. Réseau d'antennes ou station de base qui comprend un appareil selon l'une quelconque des revendications 1 à 12.

14. Réseau d'antennes ou station de base selon la revendication 13, qui comprend en outre un moyen de mesure et d'étalonnage pour recevoir les signaux couplés, et pour mesurer et étalonner l'amplitude et/ou la phase de signaux respectivement reçus depuis les, et/ou fournis aux, antennes.

15. Réseau d'antennes ou station de base selon la revendication 14, dans lequel le moyen d'étalonnage est configuré pour modifier un ou plusieurs signaux fournis aux antennes pour essentiellement maintenir un profil de faisceau requis.

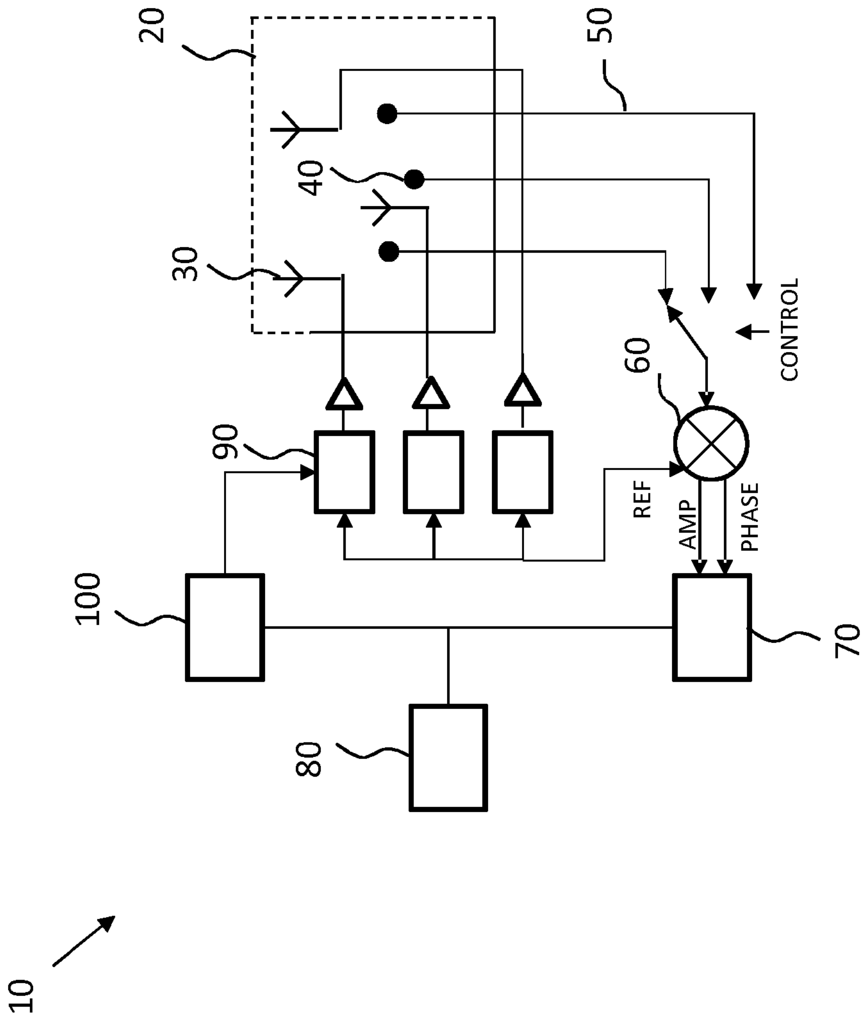

Fig. 1

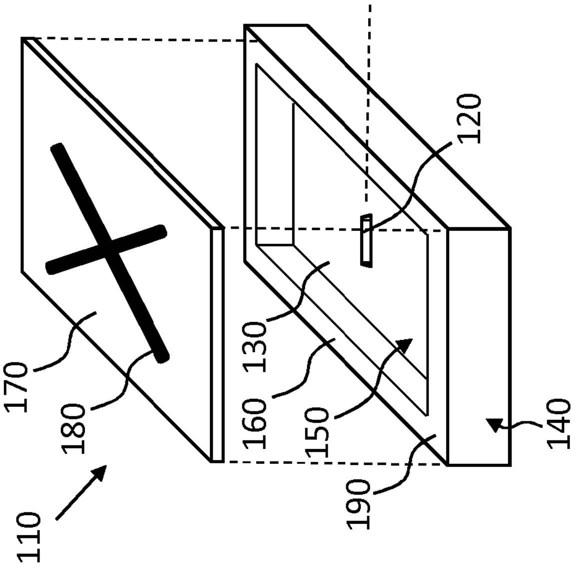

Fig. 2A

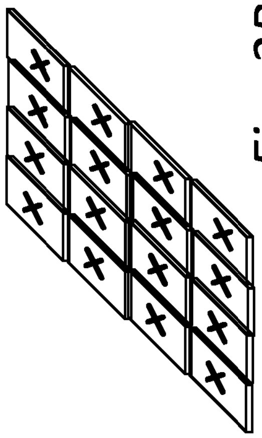

Fig. 2B

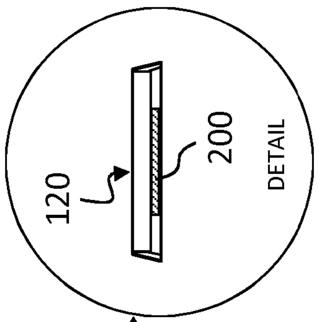

Fig. 2C

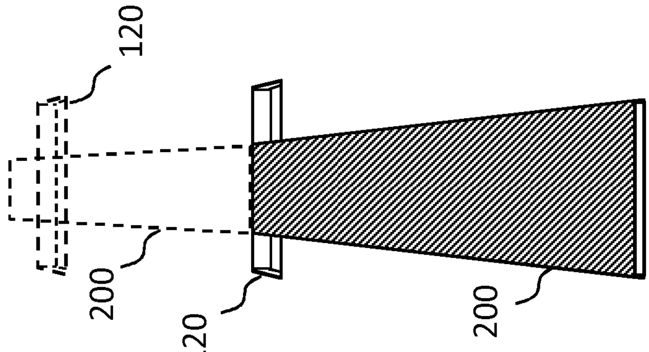

Fig. 3

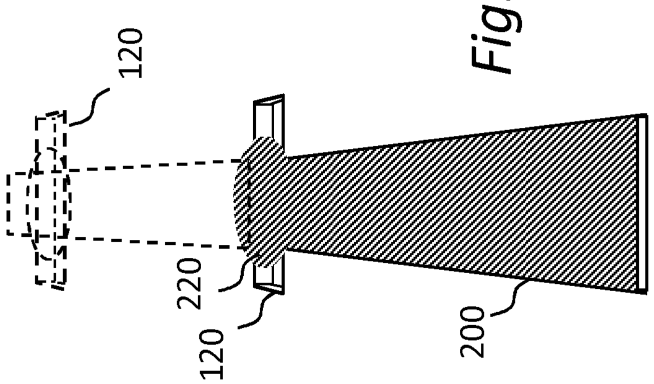

Fig. 4

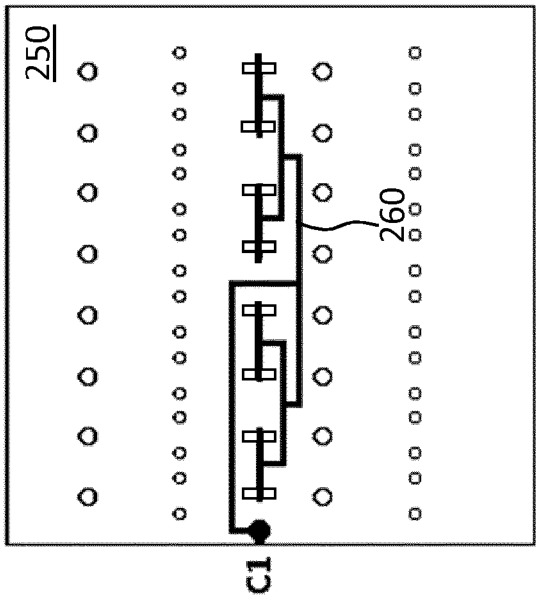

Fig. 5B

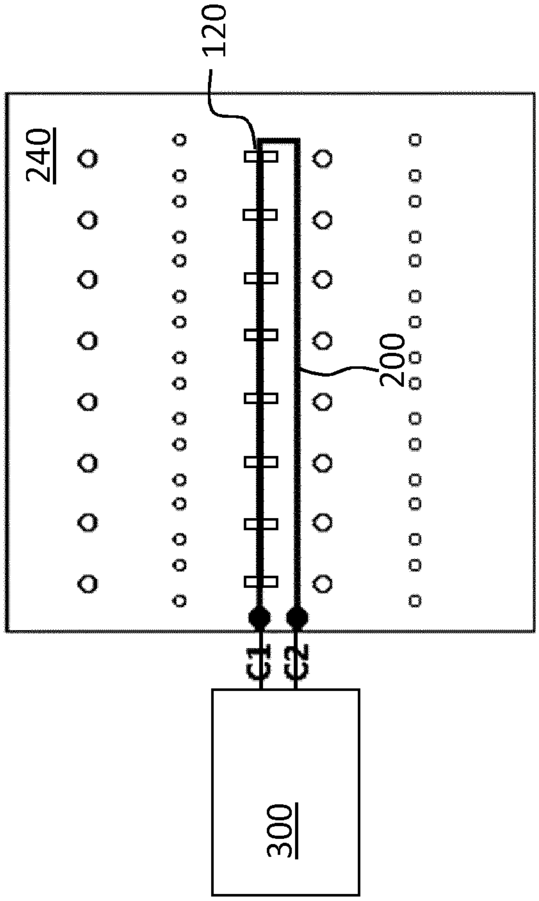

Fig. 5A

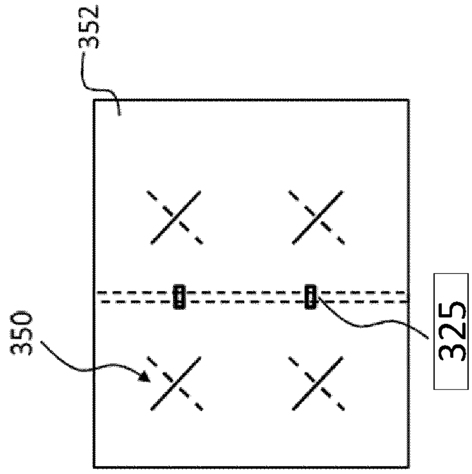

Fig. 6B

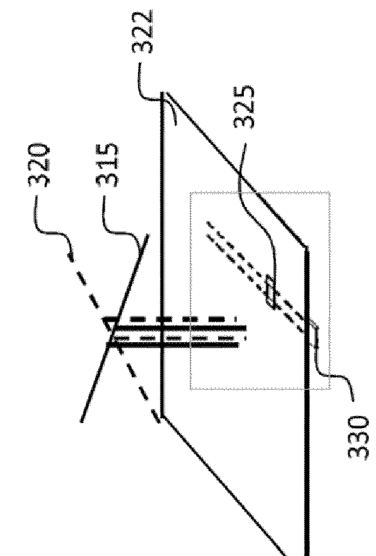

Fig. 6A

REFERENCES CITED IN THE DESCRIPTION

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