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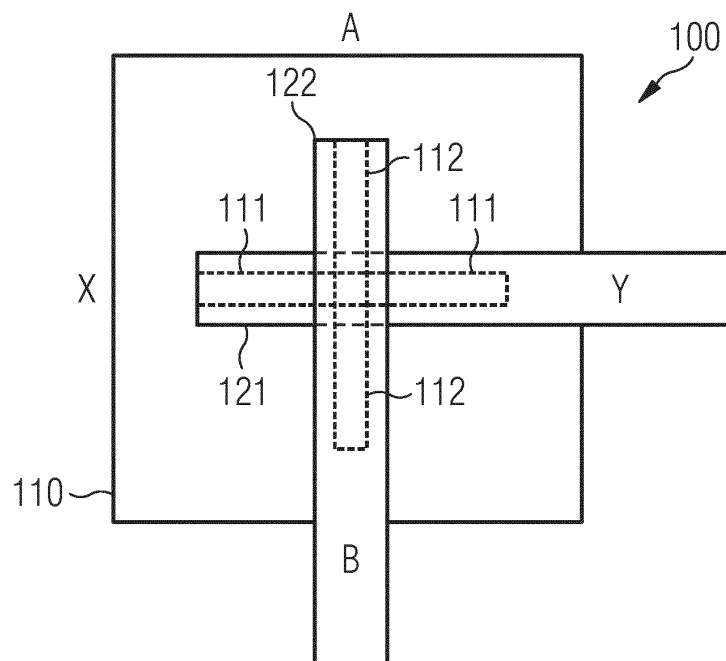
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(54) **AN APPARATUS CONFIGURED AS A RADIO FREQUENCY FEED ARRANGEMENT FOR AN ANTENNA**

(57) An apparatus configured as a radio frequency feed arrangement for an antenna comprising: a slot feed structure comprising: a first slot extending in a first direction within a conductive layer; a second slot extending in a second direction within the conductive layer, the second direction being orthogonal to the first direction, wherein the first slot and the second slot meet at a central

portion of the slot feed structure that bi-sects the first slot and bi-sects the second slot; a first feedline, electrically insulated from the conductive layer, extending adjacent the first slot; and a second feedline, insulated from the conductive layer and from the first feedline, extending adjacent the second slot.

FIG 1



Description

TECHNOLOGICAL FIELD

[0001] An apparatus and method in the field of radio frequency feed arrangements for an antenna.

BACKGROUND

[0002] A slot feed structure may be used to feed an antenna in a contactless manner.

For feeding a dual polarization slot antenna, the slot feed structure would comprise first and second slots that intersect to form a cross. The first slot excites one polarization mode and the second slot excites a different, orthogonal polarization mode.

[0003] It is desirable for these modes to be isolated from each other. However, it is difficult to maintain radio frequency (RF) isolation while feeding the slots in a simple manner.

BRIEF SUMMARY

[0004] According to various, but not necessarily all, embodiments of the invention there is provided an apparatus configured as a radio frequency feed arrangement for an antenna comprising:

a slot feed structure comprising:

a first slot extending in a first direction within a conductive layer;
a second slot extending in a second direction within the conductive layer, the second direction being orthogonal to the first direction, wherein the first slot and the second slot meet at a central portion of the slot feed structure that bi-sects the first slot and bi-sects the second slot;

a first feedline, electrically insulated from the conductive layer, extending adjacent the first slot; and
a second feedline, insulated from the conductive layer and from the first feedline, extending adjacent the second slot.

[0005] According to various, but not necessarily all, embodiments of the invention there is provided a method comprising:

providing a slot feed structure comprising:

a first slot extending in a first direction within the conductive layer
a second slot extending in a second direction within the conductive layer, the second direction being orthogonal to the first direction, wherein the

first slot and the second slot meet at a central portion that bi-sects the first slot and bi-sects the second slot;

providing a first feedline, electrically insulated from the conductive layer, extending adjacent the first slot; and

providing a second feedline, insulated from the conductive layer and from the first feedline, extending adjacent the second slot.

[0006] An apparatus configured as a radio frequency feed arrangement for an antenna comprising: a slot feed structure comprising: a slot extending in a first direction within a conductive layer; a feedline, electrically insulated from the conductive layer, extending orthogonal to the first slot. The apparatus may additionally comprise a second slot extending in a second direction within the conductive layer, the second direction being orthogonal to the first direction, wherein the first slot and the second slot meet at a central portion of the slot feed structure that bi-sects the first slot and bi-sects the second slot. The feedline may extend adjacent the second slot. The apparatus may comprise another feedline, insulated from the conductive layer and from the feedline, that extends adjacent the first slot.

[0007] According to various, but not necessarily all, embodiments of the invention there is provided examples as claimed in the appended claims.

BRIEF DESCRIPTION

[0008] For a better understanding of various examples that are useful for understanding the detailed description, reference will now be made by way of example only to the accompanying drawings in which:

Fig 1 illustrates, in plan view, an example of an apparatus configured as a radio frequency feed arrangement for an antenna;

Fig 2A illustrates an example of a first layer of the apparatus comprising a balanced slot feed structure
Fig 2A illustrates an example of a first layer of the apparatus comprising first and second feedlines

Fig 3A illustrates an example of a cross-sectional view of the apparatus illustrated in Fig 1 along the line X-Y;

Fig 3B illustrates an example of a cross-sectional view of the apparatus illustrated in Fig 1 along the line A-B;

Fig 4 illustrates an example of a two-sided printed circuit board comprising the apparatus;

Fig 5A illustrates an example plan view of system comprising the apparatus and an antenna;

Fig 5B illustrates an example of a cross-sectional view of the system along the line X-Y;

Fig 5C illustrates an example of a cross-sectional view of the system along the line A-B;

Fig 6 illustrates an example of a method.

DETAILED DESCRIPTION

[0009] Fig 1 illustrates, in plan view, an example of an apparatus 100 configured as a radio frequency feed arrangement for an antenna.

[0010] In this example, the apparatus 100 comprises a stack of first and second layers—a first layer illustrated in Fig 2A and a second parallel layer illustrated in Fig 2B. The first layer provides a balanced slot feed structure 110 of the apparatus 100. The second layer provides at least some of first and second feedlines 121, 122.

[0011] Fig 3A illustrates a cross-sectional view of the apparatus 100 illustrated in Fig 1 along the line X-Y (first direction D1). Fig 3B illustrates a cross-sectional view of the apparatus 100 illustrated in Fig 1 along the line A-B (second direction D2).

[0012] As most clearly illustrated in Fig 2A, the balanced slot feed structure 110 comprises: a first slot 111 extending in a first direction D1 within a conductive layer 114 and a second slot 112 extending in a second direction D2 within the conductive layer 114. The second direction D2 is orthogonal to the first direction D1.

[0013] The first slot 111 and the second slot 112 meet at a central portion 116 of the balanced slot feed structure 110 that bi-sects the first slot 111 and bi-sects the second slot 112.

[0014] In some but not necessarily all examples, the conductive layer 114 may be a planar layer in a defined geometry. For example, in some but not necessarily all examples, the conductive layer 114 may be a flat, planar layer and/or a curved, planar layer.

[0015] As most clearly illustrated in Fig 1, the first feedline 121 extends adjacent and overlaps at least part of the first slot 111 and the second feedline 122 extends adjacent and overlaps at least part of the second slot 112. In this figure, the slots 111, 112 are beneath the respective feedlines 121, 122 and are consequently illustrated using dotted lines.

[0016] In some but not necessarily all examples, the first feedline may be formed from a first conductive layer distinct from the conductive layer 114. In some but not necessarily all examples, the second feedline may be formed from a second conductive layer distinct from the first conductive layer and the conductive layer 114.

[0017] The first feedline 121 overlaps all or most of the first slot 111 and the second feedline 122 overlaps all or most of second slot 112. The first feedline 121 may overlap all or part of the first slot 111 lengthwise (direction D1) and/or the first feedline 121 may overlap all or part of the first slot 111 widthwise (direction D2). The second feedline 122 may overlap all or part of the second slot 112 lengthwise (direction D2) and/or the second feedline 121 may overlap all or part of the second slot 112 widthwise (direction D1). The first feedline 121 overlaps the second slot 112 only at the central portion 116 and the second feedline 122 overlaps the first slot 111 only at the

central portion 116.

[0018] Thus a length of the first slot 111 from the central portion 116 to the termination 113 compared to the length of the first feedline 121 from a position overlapping the central portion 116 to the termination 123 may be of equal length, of shorter length or longer length. A length of the second slot 112 from the central portion 116 to the termination 115 compared to the length of the second feedline 122 from a position overlapping the central portion 116 to the termination 125 may be of equal length, of shorter length or longer length.

[0019] The first feedline 121 is a first conductive strip having a width W11 in the second direction D2. In this example, but not necessarily all examples, the width W11 is greater than a width W1 of the first slot 111 in the second direction D2. The second feedline 122 is a second conductive strip having a width W12 in the first direction D1. In this example, but not necessarily all examples, the width W12 is greater than a width W2 of the second slot 112 in the first direction D1. The widths W11 and W12 may be the same or different.

[0020] As most clearly illustrated in Fig 2B and Figs 3A and 3B, the first feedline 121 is electrically insulated from the conductive layer 114 and from the second feedline 122. The second feedline 122 is electrically insulated from the conductive layer 114 and from the first feedline 121. The insulation may be an air gap or may be provided by dielectric material.

[0021] The first feedline 121 and second feedline 122 lie in a second plane 124 parallel to a first plane 117 of the conductive layer 114, except at the central portion 116 where one or both of the first feedline 121 and the second feedline 122, travel parallel to but out of the second plane.

[0022] In this particular example, the first feedline 121, travels out of the second plane 124, around the second feedline 122. The first feedline 121, diverts around the second feedline 122. The first feedline 121 has a portion 131 overlapping, but electrically insulated from the second feedline 122.

[0023] As most clearly illustrated in Fig 2A, the central portion 116 of the balanced slot feed structure 110 is an aperture, where the first slot 111 and the second slot 112 intersect. The central portion 116 has an enlarged width W3 in the second direction D2 compared to a width W1 of the first slot 111 and the central portion 16 has an enlarged width W4 in the first direction D1 compared to a width W2 of the second slot 112. The enlarged width W3 is sufficient to allow the first feedline 121 to divert around the second feedline 122 as illustrated in Fig 3A. In some but not necessarily all examples, the first feedline 121 has a reduced width where it diverts around the second feedline 122.

[0024] The central portion 116, the first and second slots 111, 112 and the balanced slot feed structure 110 have 90° rotational symmetry.

[0025] The second feedline 122 lies only in a second plane 124 parallel to and separate from the conductive

layer 114. A majority of the first feedline 121 lies in the second plane 124 parallel to the conductive layer 114 and a lower portion 131 of the first feedline 121 at the central portion 116 lies in the first plane 117 of the conductive layer 114. In the example, illustrated, but not necessarily all examples, the first feedline 121 comprises a continuous conductive line of conductive portions most of which are located in the second plane 124 and some of which are located in the first plane 117, and where all portions are interconnected electrically to form a single continuous conductive line.

[0026] In some but not necessarily all examples, the electrical length of the first feedline 121 from the central portion 116 to a termination 123 is a quarter of a wavelength ($\lambda/4$) associated with a resonant frequency of the antenna 200. In some but not necessarily all examples, the electrical length of the second feedline 122 from the central portion 116 to a termination 125 is a quarter of the wavelength ($\lambda/4$) associated with the resonant frequency of the antenna 200.

[0027] The electrical length of an electrical conductor is measured in terms of the phase shift introduced by transmission over that conductor at the resonant frequency of the antenna. An electrical length of $\lambda/4$ introduces a phase shift of $\pi/2$ radians.

[0028] In some but not necessarily all examples, the physical length of the first feedline 121 from the central portion 116 to a termination 123 is not exactly a quarter of a wavelength ($\lambda/4$) associated with a resonant frequency of the antenna 200. The exact physical length required may be dependent upon adjacent dielectric material.

[0029] In some but not necessarily all examples, the physical length of the second feedline 122 from the central portion 116 to a termination 125 is not exactly a quarter of the wavelength ($\lambda/4$) associated with the resonant frequency of the antenna 200. The exact physical length required may be dependent upon adjacent dielectric material.

[0030] As can best be seen from Fig 3A, in some examples, the termination 123 of the first feedline 121 is vertically aligned with a termination 113 of the first slot 111. As can best be seen from Fig 3B, in some examples, the termination 125 of the second feedline 122 is aligned with a termination 115 of the second slot 112.

[0031] As can best be seen from Fig 2B, the first feedline 121 does not split and has only a single termination 123. The second feedline 122 does not split and has only a single termination 125.

[0032] The termination 123 forms an electrical open circuit, also known as an electrical open end. The termination 125 forms an electrical open circuit, also known as an electrical open end.

[0033] The apparatus 100 has no feedlines other than first and second feedlines 121, 122.

[0034] The electrical length of the first slot 111 is a half wavelength ($\lambda/2$) associated with a resonant frequency of the antenna 200. The electrical length of the second slot 112 is a half wavelength ($\lambda/2$) associated with the

resonant frequency of the antenna 200.

[0035] As a consequence of the electrical lengths of the first slot 111, first feedline 121, second slot 112 and second feedline 122, the electric field associated with the first slot 111 has a null at or near the central portion 116 and the electric field associated with the second slot 112 has a null at or near the central portion 116. This results in enhanced isolation of the dual polarization modes of the apparatus 100.

[0036] In the examples of Figs 1, 2a, 2B, 3A and 3B, it should be appreciated that when implemented the slots 111, 112 and the feedlines 121, 122 may have more elongate aspect ratios than illustrated. That is the ratio of width to length may be less when implemented than as illustrated.

[0037] The widths W11 and W12 may be the same. The widths W1 and W2 may be the same. The widths W3 and W4 may be the same.

[0038] Fig 4 illustrates an example of a two-sided printed circuit board 300 comprising a first side 301 and a second side 302, opposing the first side. The first side 301 provides the conductive layer 114, first slot 111, second slot 112 and central portion 131 of the first feedline 121. The second side 302 provides, via selective metalization, the remaining portions of the first feedline 121 and all of the second feedline 122.

[0039] Vias 140 through the two-sided printed circuit board 300 electrically interconnect the central portion 131 of the first feedline 121 (first side 301) with the remaining portions of the first feedline 121 (second side 301).

[0040] In other examples, a jumper component could be used to electrically interconnect the distinct portions of the first feedline 121 in the second plane 124 instead or routing an interconnecting portion of the first feedline 121 out of the second plane 124.

[0041] Fig 5A illustrates an example plan view of system 201 comprising the apparatus 100 and, optionally, an antenna 200.

[0042] The perspective is a similar perspective to Fig 1. Fig 5B illustrates a cross-sectional view of the system 201 along the line X-Y, a similar perspective to Fig 3A. Fig 5C illustrates a cross-sectional view of the system 201 along the line A-B, a similar perspective to Fig 3B.

[0043] A central portion 216 of the antenna 200 overlaps the central portion 116 of the slot feed structure 110.

[0044] In the illustrated example, the first feedline 121 and the second feedline 122 extend in a plane 124 that is positioned between the antenna 200 and the plane 117 of the conductive layer 114 of the balanced slot feed structure 110.

[0045] In other examples, the conductive layer 114 of the balanced slot feed structure 110 extends in a layer that is positioned between the antenna 200 and the plane 117 of the first feedline 121 and the second feedline 122. That is the antenna 200 is positioned on the opposite side, to that illustrated in the figure.

[0046] In this but not necessarily all examples, the antenna 200 is a dual polarization antenna.

[0047] In this but not necessarily all examples, the antenna 200 is a patch antenna. However, other antennas that are excited by slots may be used such as, for example, a dielectric resonator antenna.

[0048] In other examples, the system 201 comprises the apparatus 100 but does not comprise the additional radiator structure 200. The balanced slot feed structure 110 operates as a radiator.

[0049] The system 201 may be any suitable equipment or device. There follows a non-exhaustive list of receiver and/or transmitter equipment:

- (a) a base station or network device which is fixed/stationary and which comprises an antenna array of multiple antenna radiator elements.
- (b) A mobile or hand portable electronic device having an array of antenna radiator elements or a single antenna radiator, for example, and not limited to, a mobile phone, a smartphone, a navigation device, a multimedia player, a laptop, a tablet computer, a camera, etc.
- (c) A vehicle carrying a radio system and an antenna or antenna array, for example, and not limited to, an aircraft, an automobile, a train, a bicycle, a motorcycle, etc.

The receiver and/or transmitter equipment typically comprise radio frequency circuitry coupled to the apparatus 100 that provides the radio frequency feed arrangement to the antenna 200. The radio frequency circuitry may be coupled to the first feedline 121 and/or the second feedline 122 of the apparatus 100. The radio frequency circuitry may comprise at least one of receiver circuitry, transmitter circuitry, and both receiver and transmitter circuitry.

Fig 6 illustrates an example of a method 400 comprising:

at block 402, providing a balanced slot feed structure comprising:

- a first slot 111 extending in a first direction within the conductive layer
- a second slot 112 extending in a second direction within the conductive layer, the second direction being orthogonal to the first direction, wherein the first slot 111 and the second slot 112 meet at a central portion 116 that bi-sects the first slot 111 and bi-sects the second slot 112;

at block 404, providing a first feedline 121, electrically insulated from the conductive layer, extending adjacent the first slot 111; and

at block 406, providing a second feedline 122, insulated from the conductive layer and from the first feedline 121, extending adjacent the second slot 112.

[0050] Where a structural feature has been described, it may be replaced by means for performing one or more of the functions of the structural feature whether that function or those functions are explicitly or implicitly described.

[0051] The apparatus and system may be configured to operate in one or more operational resonant frequency bands. For example, the operational frequency bands may include (but are not limited to) Long Term Evolution (LTE) (US) (734 to 746 MHz and 869 to 894 MHz), Long Term Evolution (LTE) (rest of the world) (791 to 821 MHz and 925 to 960 MHz), amplitude modulation (AM) radio (0.535-1.705 MHz); frequency modulation (FM) radio (76-108 MHz); Bluetooth (2400-2483.5 MHz); wireless local area network (WLAN) (2400-2483.5 MHz); hyper local area network (HiperLAN) (5150-5850 MHz); global positioning system (GPS) (1570.42-1580.42 MHz); US - Global system for mobile communications (US-GSM) 850 (824-894 MHz) and 1900 (1850 - 1990 MHz); European global system for mobile communications (EGSM) 900 (880-960 MHz) and 1800 (1710 - 1880 MHz); European wideband code division multiple access (EU-WCDMA) 900 (880-960 MHz); personal communications network (PCN/DCS) 1800 (1710-1880 MHz); US wideband code division multiple access (US-WCDMA) 1700 (transmit: 1710 to 1755 MHz, receive: 2110 to 2155 MHz) and 1900 (1850-1990 MHz); wideband code division multiple access (WCDMA) 2100 (transmit: 1920-1980 MHz, receive: 2110-2180 MHz); personal communications service (PCS) 1900 (1850-1990 MHz); time division synchronous code division multiple access (TD-SCDMA) (1900 MHz to 1920 MHz, 2010 MHz to 2025 MHz), ultra wideband (UWB) Lower (3100-4900 MHz); UWB Upper (6000-10600 MHz); digital video broadcasting - handheld (DVB-H) (470-702 MHz); DVB-H US (1670-1675 MHz); digital radio mondiale (DRM) (0.15-30 MHz); worldwide interoperability for microwave access (WiMax) (2300-2400 MHz, 2305-2360 MHz, 2496-2690 MHz, 3300-3400 MHz, 3400-3800 MHz, 5250-5875 MHz); digital audio broadcasting (DAB) (174.928-239.2 MHz, 1452.96- 1490.62 MHz); radio frequency identification low frequency (RFID LF) (0.125-0.134 MHz); radio frequency identification high frequency (RFID HF) (13.56-13.56 MHz); radio frequency identification ultra high frequency (RFID UHF) (433 MHz, 865-956 MHz, 2450 MHz).

[0052] The operational frequency bands may for example also extend to future operational frequency bands when they are defined such as, for example, 5G operational frequency bands.

[0053] A frequency band over which an antenna can efficiently operate is a frequency range where the antenna's return loss is less than an operational threshold. For example, efficient operation may occur when the antenna's return loss is better than (that is, less than) -4dB or -6dB.

[0054] As used here 'module' refers to a unit or apparatus that excludes certain parts/components that would

be added by an end manufacturer or a user. The apparatus 100 may be a module. The antenna 200 may be a module. The system may be a module.

[0055] The term 'comprise' is used in this document with an inclusive not an exclusive meaning. That is any reference to X comprising Y indicates that X may comprise only one Y or may comprise more than one Y. If it is intended to use 'comprise' with an exclusive meaning then it will be made clear in the context by referring to "comprising only one" or by using "consisting".

[0056] In this brief description, reference has been made to various examples. The description of features or functions in relation to an example indicates that those features or functions are present in that example. The use of the term 'example' or 'for example' or 'may' in the text denotes, whether explicitly stated or not, that such features or functions are present in at least the described example, whether described as an example or not, and that they can be, but are not necessarily, present in some of or all other examples. Thus 'example', 'for example' or 'may' refers to a particular instance in a class of examples. A property of the instance can be a property of only that instance or a property of the class or a property of a sub-class of the class that includes some but not all of the instances in the class. It is therefore implicitly disclosed that a features described with reference to one example but not with reference to another example, can where possible be used in that other example but does not necessarily have to be used in that other example.

[0057] Although embodiments of the present invention have been described in the preceding paragraphs with reference to various examples, it should be appreciated that modifications to the examples given can be made without departing from the scope of the invention as claimed.

[0058] Features described in the preceding description may be used in combinations other than the combinations explicitly described.

[0059] Although functions have been described with reference to certain features, those functions may be performable by other features whether described or not.

[0060] Although features have been described with reference to certain embodiments, those features may also be present in other embodiments whether described or not.

[0061] Whilst endeavoring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

Claims

1. An apparatus configured as a radio frequency feed arrangement for an antenna comprising:

a slot feed structure comprising:

a first slot extending in a first direction within a conductive layer;
a second slot extending in a second direction within the conductive layer, the second direction being orthogonal to the first direction, wherein the first slot and the second slot meet at a central portion of the slot feed structure that bi-sects the first slot and bi-sects the second slot;

a first feedline, electrically insulated from the conductive layer, extending adjacent the first slot; and
a second feedline, insulated from the conductive layer and from the first feedline, extending adjacent the second slot.

2. An apparatus as claimed in any preceding claim, wherein the first feedline overlaps all or most of the first slot and the second feedline overlaps all or most of second slot.
3. An apparatus as claimed in any preceding claim, wherein the first feedline overlaps the second slot only at the central portion and the second feedline overlaps the first slot only at the central portion.
4. An apparatus as claimed in any preceding claim, wherein the first feedline, diverts around the second feedline at the central portion.
5. An apparatus as claimed in any preceding claim, wherein the first feedline and second feedline lie in a second plane parallel to the conductive layer, except at the central portion where one or both of the first feedline and second feedline, travel parallel to but out of the second plane.
6. An apparatus as claimed in any preceding claim, wherein the central portion has an enlarged width in the second direction compared to a width of the first feedline and wherein the central portion has an enlarged width in the first direction compared to a width of the second feedline.
7. An apparatus as claimed in claim 6, wherein the central portion of enlarged width enables the first feedline to divert around the second feedline.
8. An apparatus as claimed in any preceding claim, wherein the second feedline lies only in the plane parallel to the conductive layer, a majority of the first feedline lies in the plane parallel to the conductive layer and a portion of the first feedline at the central portion lies in the plane of the conductive layer.

9. An apparatus as claimed in any preceding claim, wherein the electrical length of the first feedline from the central portion to a termination is a quarter of a wavelength associated with a resonant frequency band of the antenna and wherein the electrical length of second feedline from the central portion to a termination is a quarter of the wavelength associated with the resonant frequency band of the antenna. 5
10. An apparatus as claimed in any preceding claim, wherein a termination of the first feedline is aligned with a termination of the first slot and wherein a termination of the second feedline is aligned with a termination of the second slot, wherein the first feedline does not split and has only a single termination and the second feedline does not split and has only a single termination. 10 15
11. An apparatus as claimed in any preceding claim, wherein the electrical length of the first slot is a half wavelength $\lambda/2$ associated with a resonant frequency of the antenna and wherein the electrical length of the second slot is a half wavelength $\lambda/2$ associated with the resonant frequency of the antenna. 20 25
12. An apparatus as claimed in any preceding claim, wherein a two-sided printed circuit board comprises a first side and a second side, the first side providing the conductive layer and the second side providing, via selective metallization, at least portions of the first feedline and the second feedline. 30
13. A system comprising the apparatus as claimed in any preceding claim, and an antenna, wherein a central portion of the antenna overlaps the central portion of the slot feed structure. 35
14. Receiver and/or transmitter equipment comprising the apparatus as claimed in any of claims 1 to 12, and further comprising radio frequency circuitry coupled to the first feedline and/or the second feedline of the apparatus. 40
15. A method comprising: 45
- providing a slot feed structure comprising:
- a first slot extending in a first direction within the conductive layer
- a second slot extending in a second direction within the conductive layer, the second direction being orthogonal to the first direction, wherein the 50
- first slot and the second slot meet at a central portion that bi-sects the first slot and bi-sects the second slot; 55
- providing a first feedline, electrically insulated
- from the conductive layer, extending adjacent the first slot; and
- providing a second feedline, insulated from the conductive layer and from the first feedline, extending adjacent the second slot.

FIG 1

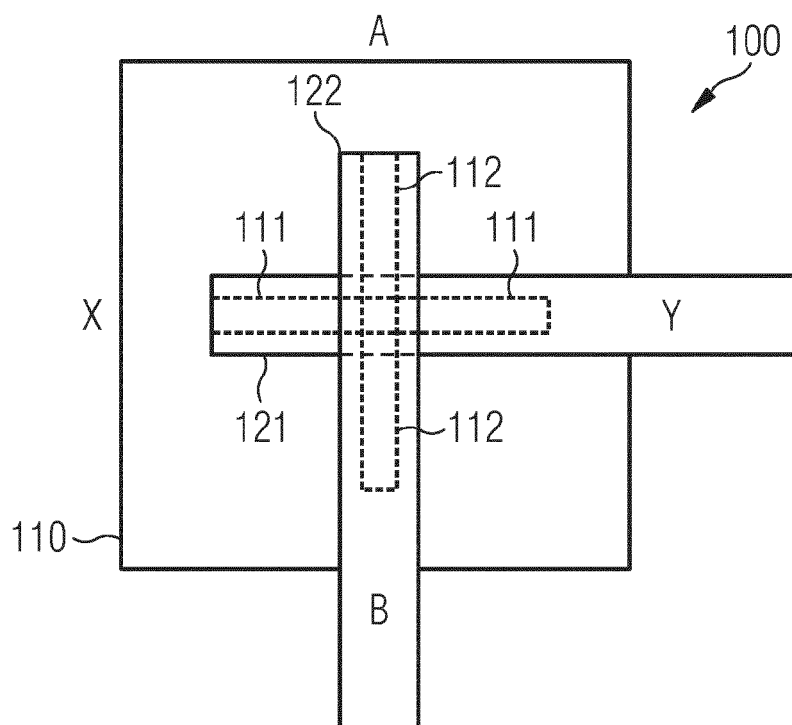


FIG 2A

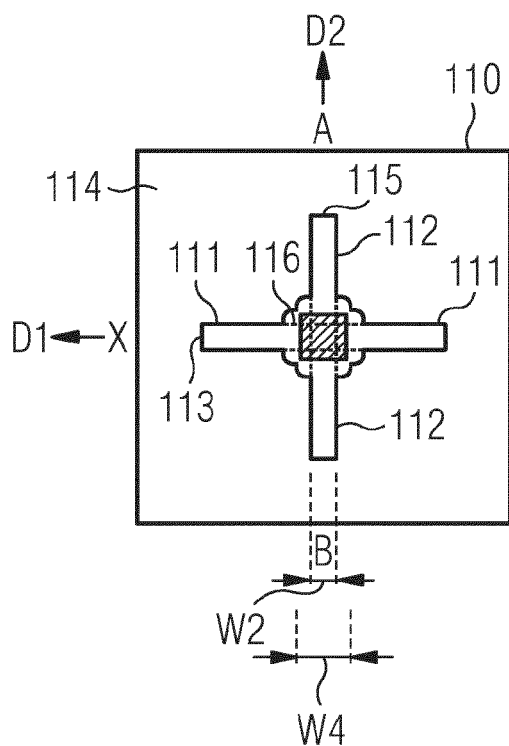


FIG 2B

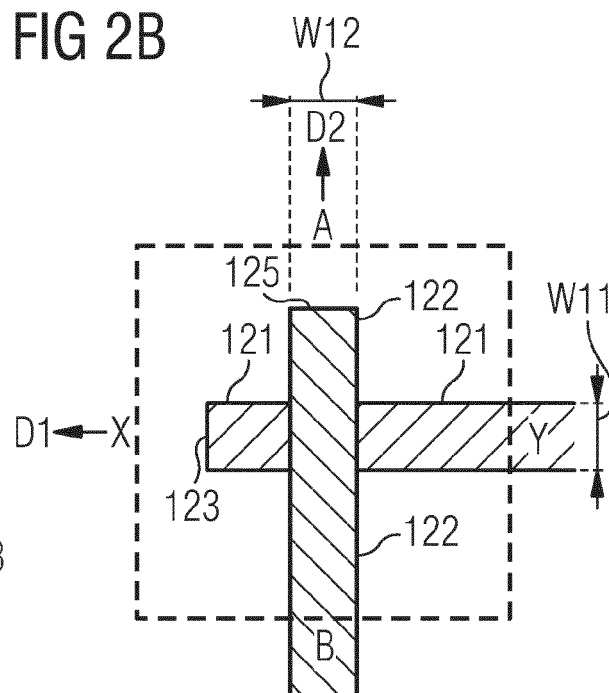


FIG 3A

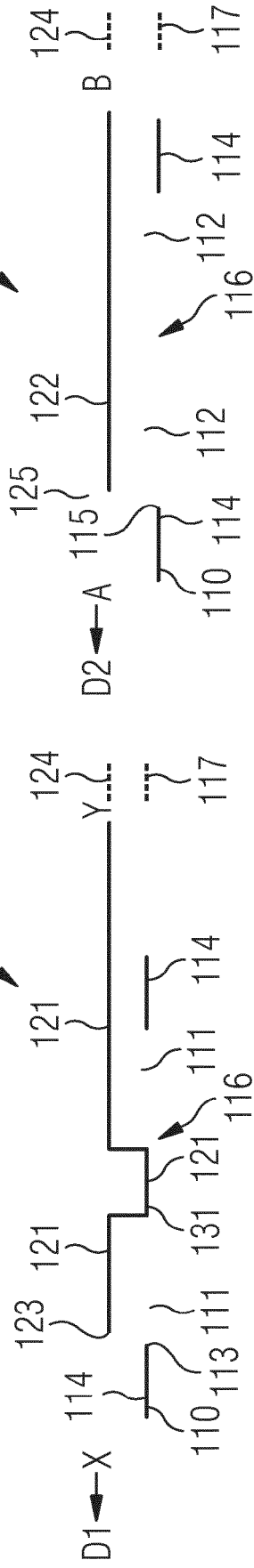


FIG 3B

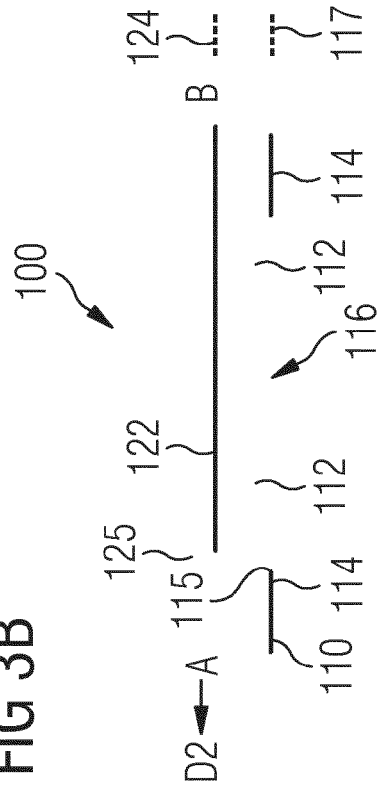


FIG 4

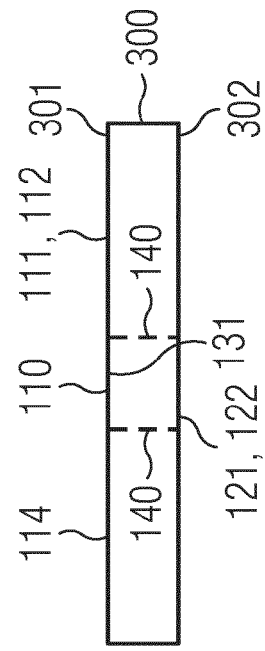


FIG 5A

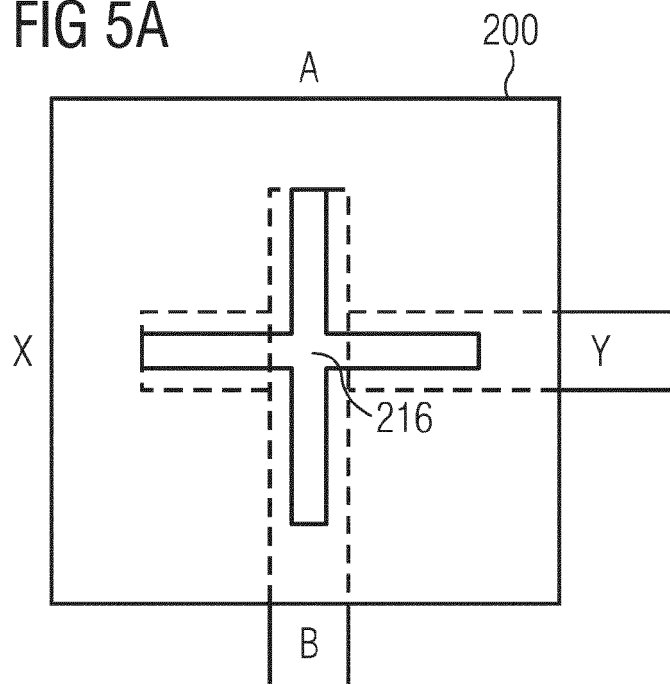


FIG 5B

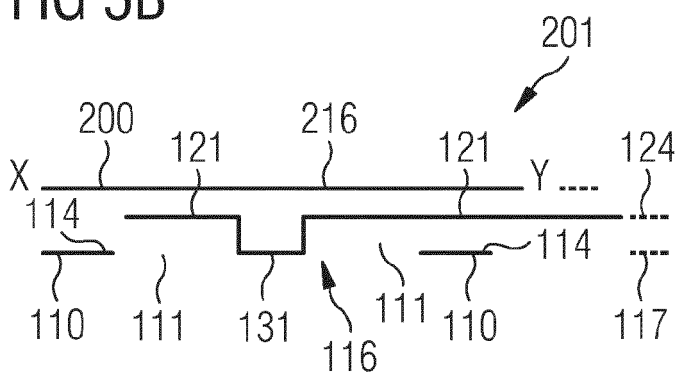


FIG 5C

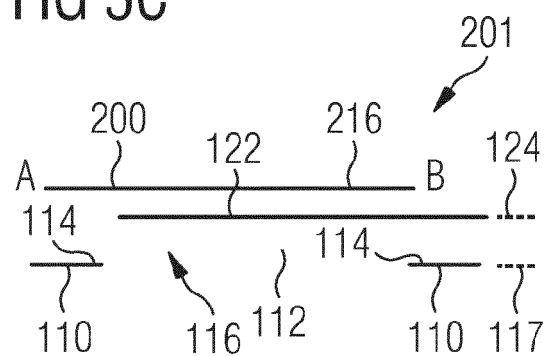
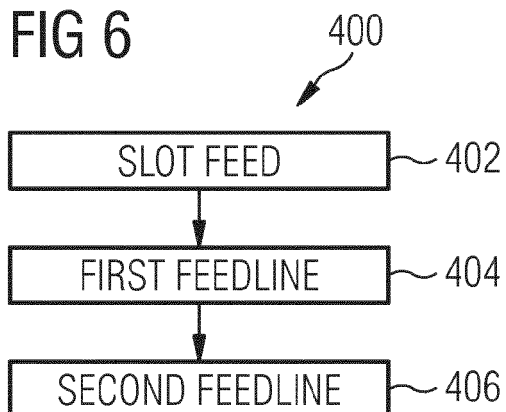


FIG 6





EUROPEAN SEARCH REPORT

Application Number
EP 17 16 2075

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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			H01Q
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 15 September 2017	Examiner Yvonnet, Yannick
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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