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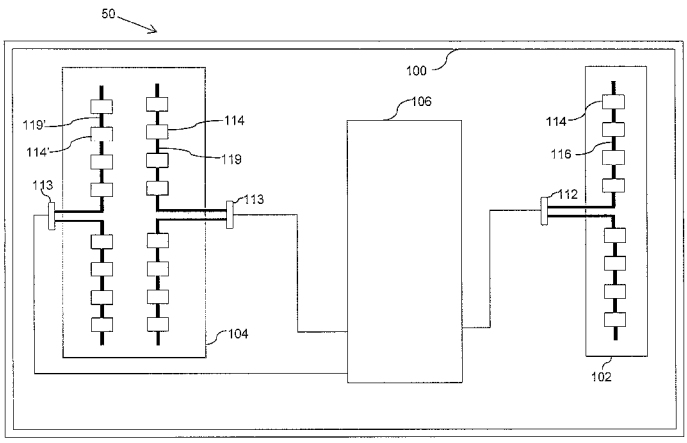


FIG. 1

(57) Abstract: The present invention relates to a printed circuit board (100) for a radar system (50) for short range detection of objects, comprising a microstrip patch array transmit antenna (102) arranged for transmission of radiation, a microstrip patch array receive antenna (104) arranged for reception of radiation and electronics (106) for radar and signal processing, where the electronics (106) are arranged for feeding to the transmit antenna (102), feeding from the receive antenna (104), and signal processing, wherein the printed circuit board (100) comprises a metal frame (408) arranged around the transmit antenna (102) for isolation between transmit antenna(102), receive antenna (104) and electronics (106), and the printed circuit board (100) comprises a metal frame (408) arranged around the receive antenna (104) for isolation between transmit antenna (102), receive antenna (104) and electronics (106). The present invention also relates to a radar system (50) for short range detection of objects, comprising a printed circuit board (100), wherein the radar system (50) comprises conductive side walls (510) arranged around the transmit antenna (102) co-operating with the metal frame (408), for isolation between transmit antenna (102), receive antenna (104) and electronics (106), the radar system (50) comprises conductive side walls (510) arranged around the receive antenna (104) cooperating with the metal frame (408), for isolation between transmit antenna (102), receive antenna (104) and electronics (106).

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SHORT RANGE RADAR SYSTEM

FIELD OF INVENTION

The present invention relates to a short range radar system, with microstrip patch array antennas, antenna systems and electronics arranged for wide coverage short range radar.

BACKGROUND OF THE INVENTION

The radar solutions of today are limited to an exclusive group of users due the expensive technology required for beneficial solutions and the fact that radar installations range in size from somewhat physically voluminous for handheld or carried by a vehicle, to very large fixed installations.

A radar system is compiled of antennas for transmission and reception, as well as electronics. In many cases the same physical antenna is used for both transmission and reception. Some times separate antennas are required for transmission and reception. The performance provided by a radar system depends on the system architecture as well as the performance figures of different parts and components in the system, and on a balance of compromises given by boundary conditions. Examples of such boundary conditions may be related to: characteristics given by a certain wavelength, distance between a transmit antenna and a receive antenna, transmission effect, signal processing accuracy, and desired product lifetime or service intervals.

By example a radar system to cover horizontally 360 degrees may require a rotating antenna solution. Such a solution will need mechanics and service in order to operate over time. If only a limited section of the horizon is considered interesting, a fixed antenna solution with at least two separate phase coherent RF-channels in reception using so called monopulse technology could be used for determining the angular position of an object.

Many times arrays of rectangular patches are used. Often separate antennas are employed for transmit and receive functions, especially when CW radar (Continuous Wave radar) is considered but often also for pulsed applications since one wants to use the receiver also while transmitting a pulse. In both cases it is necessary to have good signal isolation between the transmitter and receiver.

In surveillance applications a common application might be monitoring of a certain territory or property. Examples might be installations like power plants, production facilities of sensitive nature, or people and operations exposed to risks. Objects desired to monitor in such applications may include objects, people and/or vehicles approaching a particular area or point.

Small mechanical dimensions of a radar system are advantageous when a system is desired to harmonize with the surroundings. Small mechanical dimensions of a radar system are also advantageous, when a system is installed on a vehicle or handheld. The size of the system (concerning gain, lobe widths etc) is in general inversely proportional to the frequency used.

An array antenna for radar applications realized in PCB (Printed Circuit Board) technology is described in US 5422649. This document presents a predominantly series fed microstrip array antenna for vertically polarized fan beam for C-band SAR applications with a physical area of 1,7 m (height) by 0,17 m (width) comprising two rows of patch elements and employing a parallel feed to left- and right-half sections of the rows. Two rows of array elements are excited from opposite directions with opposite (180° difference) phase in order to create a beam in the broadside. This particular feed arrangement generates low level of stray radiation (from feed lines, power dividers, impedance transformers etc) and low cross polarisation for the main cuts (vertical plane and horizontal plane) due to the (anti) symmetry arrangement of the horizontal feed lines and the symmetry of the two halves. However, this advantage only occurs for a rather small angle of interval with respect to the main cuts due to the (with respect to wavelength) large spacing between the long horizontal feed lines and the comparatively long distance between the vertical feed lines. Furthermore, the length of transmission line (with respect to wavelength) per element is rather large and as a consequence the line loss per element is rather high. An antenna with these dimensions is not practical for particular applications, where small dimensions are desired.

In US 2009/0009399 various concepts for feeding patch arrays are presented. These concepts provide solutions which also cause a low level of stray radiation using balanced feed lines in the form of CPS lines (Coplanar Strip Lines). Moreover, in US 2009/0009399 CPW (Coplanar Wave Guides) are used requiring transitions (baluns) between the unbalanced CPW and the CPS-lines, baluns which might be difficult to manufacture. Moreover, CPS and CPW technology require small dimensions and high tolerances.

SUMMARY OF THE INVENTION

The present invention relates to a short range wide coverage radar system, including a transmit antenna and a receive antenna, both with linear polarisation. An objective of the presented invention is to provide a radar system with small mechanical dimensions and with a wide H-plane coverage. In an embodiment a radar coverage may typically be provided up to approximately 90 degrees horizontally and 15 degrees vertically, coinciding with the E-plane. The term H-plane means the principal plane which the magnetic field is parallel to. The term E-plane means the principal plane which the electric field is parallel to. Such a radar system may be used in surveillance applications, automotive applications, and other similar applications.

The invention described includes the transmit antenna, the receive antenna and electronics. The electronics includes: a power distributing network to feed the transmit antenna, a power distributing network to feed the receive antenna, and electronics for signal processing.

The invention herein described presents a series fed microstrip antenna system where each sub array antenna is centrally fed via two closely spaced microstrip feed lines which are opposite in phase causing low level of stray radiation with respect to a large solid angle. The length of transmission line (with respect to wavelength) per element is short, and as a consequence the line loss is low, which is advantageous in a radar system.

The present invention relates to conductive side-walls arranged around the transmit antenna and around the receive antenna. The side walls arranged around the receive antenna widen the antenna element patterns with respect to the H-plane.

Conductive side-walls are advantageous when a wide coverage radar solution is desired. The conductive side walls will help to widen the radar lobe of the receive antenna with respect to the H-plane.

Conductive side walls are also advantageous because they shield stray radiation between antennas and electronics. Without conductive side walls and the particular radome arrangement the antennas would have to be positioned apart with a significant larger distance, and stray radiation would harm the performance of the radar system.

An embodiment includes a lens arrangement in front of the transmit antenna to widen the beam width with respect to H-plane. This solution may also include a lens arrangement in front of the receive antenna.

A concave lens in front of the transmit antenna is advantageous to provide a wider antenna lobe. A concave lens in front of the receive antenna is advantageous to provide a wider antenna lobe.

A preferred implementation of the antennas is by series fed microstrip patch array antennas. In an embodiment the transmit antenna, the receive antenna and the electronics are arranged on the same printed circuit board (PCB).

The microstrip patch array antenna is advantageous because it can be integrated directly on a PCB. Implementing a transmit antenna and a receive antenna, and electronics on the same PCB is advantageous to keep production cost low.

In an embodiment the transmit antenna is centre fed. The feed to the transmit antenna may be implemented via a power splitter into two transmit microstrip lines. The lengths of the two transmit microstrip lines, between the power splitter and transmit antenna, differ half a guide wavelength in order for the transmit antenna to radiate in phase in a direction normal to the surface. The term guide wavelength λ_g means the wavelength of the wave guided by the microstrip line. The receive microstrip lines from the receive antenna are merged via a power conjunction into one feed line. The lengths of the two receive microstrip lines between the power conjunction and receive antenna, differ half a guide wavelength in order for the receive antenna to radiate in phase in a direction normal to the surface.

An advantage of having a feed line split into two/merged into one, with the lengths differing half a wavelength, and with the conjunction separated and shielded from the antenna cavity is that stray radiation originating from the feed lines is reduced and thereby side lobe levels are decreased.

In many cases an inner cover is desired in addition. The inner cover unit is arranged over the electronics and the power splitter. The inner cover has walls joining a metal frame on the PCB. The inner cover works as a shield between the antennas and the electronics.

The inner cover has an isolating effect on stray radiation from the electronics and the power splitter, as well as stray radiation from the antennas influencing the electronics.

In another embodiment, a radome for protection of the antennas and the electronics is arranged to cover the antennas and the electronics. The transmit lens and the receive lens, are in an embodiment, integrated in the radome.

The radome is advantageously protecting the antennas and electronics from unwanted physical effect, as well as possibly carrying a desired shape and colour.

An advantage of integrating transmit lens and receive lens in the radome 702, is to limit the number of parts and simplify the assembly, and thereby reduce production costs.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig 1. shows a radar system 50.

Fig 2 shows arrays 107 and sub arrays 109.

Fig 3. shows transmit antenna 102 and receive antenna 104.

Fig 4. shows side walls 510, inner walls 512 and roof 514.

Fig 5A. shows transmit lens 604 and receive lens 610.

Fig 5B. shows radar system 50 including radome 702.

If the same number appears in different figures, it is the same unit shown in the different figures.

DESCRIPTION OF EMBODIMENTS

Fig. 1 shows a radar system 50, including a PCB 100 (also referred to as printed circuit board) with a transmit antenna 102, a receive antenna 104, and electronics 106. All parts arranged on the single PCB 100. The transmit antenna 102 is also referred to as microstrip patch array transmit antenna, and the receive antenna 104 is also referred to as microstrip patch array receive antenna. Fig. 1 further shows the electronics 106 connected to power splitters 112 and 113, feeding the antennas 102 and 104 via transmit microstrip lines 116 and receive microstrip lines 119. The antennas 102 and 104 include patches 114, which are interconnected by the microstrip lines 116 and 119 respectively.

The different parts of an antenna are described in Fig. 2. in more detail.

Even if the figures show all components arranged on a single PCB, in an embodiment all other described embodiments may be implemented on a plurality of PCB's.

Fig. 2 shows the transmit antenna 102 and receive antenna 104, the antennas formed by arrays 107. An array 107 may include one or a plurality of columns 108, with each column 108 divided into sub arrays 109. Each sub array 109 is built by patches 114

fed in series, by microstrip lines 116 and 119. Each sub array may be ended by a microstrip stub 111.

As shown in Fig. 2 the transmit antenna 102, includes a centrally fed array 107, fed via one channel. Two sub arrays 109 form a column 108. An array may optionally comprise a plurality of columns 108. Such arrangement provides a broad beam in the H-plane and a narrow in the E-plane. Each sub array 109 of the centrally feed array 107 of patch elements 114 (patch elements may also be referred to as patches) is, according to the figure, ended by an open microstrip stub 111.

Further Fig. 2 shows the receive antenna 104, which includes two channels, formed by two centrally fed columns 108, i.e. two columns of patches 114, positioned side by side. The two channels signals may be superposed arbitrarily in amplitude and phase. In an embodiment, sum and difference modes in reception may be used. This is advantageous for determining a position of a target with respect to the horizontal plane, coinciding with the H-plane in the embodiment.

In Fig. 2 (and other figures as well) the patches 114 in each array 107 appears to be equal in size, but in general, each sub array is preferably tapered, whereby the width differs slightly from individual patch to patch within each sub array in order to radiate according to a prescribed function with respect to amplitude and phase together with its opposite half sub array 109. In an embodiment, all sub arrays 109, are substantially equal in size. By other words sub arrays 109 in an array 107 are mirrored. According to an embodiment in the particular system, a sampled Taylor distribution is chosen. This is one example of methods to be used for designing the array 107. Other distributions to be used for designing the array 107 include Chebyshev taper. Yet another distribution is given by that obtained when the patches are all equal in size.

Each sub array 109 is designed in a “travelling wave sense” meaning that, when seen as a transmitter, a time harmonic wave incident from the feed line sees a matched antenna and the wave decouples successively into free space by the patches 114. When the wave has passed the last patch 114 virtually all energy has been decoupled into free space and only a few per cent may be left to cause reflection and stray radiation at the open microstrip stub 111. This requires that each patch 114 is well matched in its surrounding and the level of internal reflection is low.

In an embodiment, the open microstrip stub 111 reaches effectively about one quarter of a guide wavelength from the end of the last patch 114 referring to the wavelength in the transmit microstrip line 116.

An alternative embodiment, not shown in Fig.2, to the open microstrip stub 111, is to end with a terminating resistor and with a quarter wave stub after the terminating resistor.

Yet another alternative embodiment, not shown in the figure, is to short circuit the microstrip line 116, to the antenna ground plane of the PCB 100, immediately after the terminating resistor. Such shortcut could e.g. be implemented using via holes. Via holes is a term used to describe electrical connections between different layers in a PCB 100.

Yet another alternative embodiment is to omit the quarter wave stub and short circuit the end of the last patch in each sub array to the antenna ground plane. Such shortcut could e.g. be implemented using via holes.

In order for each sub array to radiate efficiently, each patch 114 should preferably radiate a considerable amount of the incoming power. An example may be for each patch 114 to radiate up to about 50% of the incoming power. Other examples may be up to 33%, or up to 66%. For a patch 114 to radiate 50% of the incoming power in a series fed array of the type considered, the patch 114 width has to be rather large, typically about $\lambda_0/2$ for a substrate with relative permittivity 3.66 and height $0.027\lambda_0$, where λ_0 denotes free space wavelength. This means that unless precautions are taken the beam width in the H-plane will be considerably less than 90° which is the theoretical limit. The aim is to have a wide element beam width, as close to the theoretical patch beam width with respect to H-plane as possible.

For a given fraction of the incident power to be radiated by a patch 114, a thicker laminate requires a smaller patch 114 width and a thinner laminate requires a larger patch 114 width. There are however other limiting factors for how wide the patch 114 can be, especially when put in an array of columns as in the case of the receive antenna 104. A thick laminate is not good either since it will cause more stray radiation from lines, bends and other details necessary to distribute the power in the antenna.

According to an embodiment the patches 114 in a column 108 electrically have substantially the same distance between them. This means that the time to travel for a guided wave λ_g is in principal the same between each patch 14.

According to an embodiment the patches 114 in a column 108 have substantially the same physical distance between them.

In an embodiment the transmit antenna 102 and the receive antenna 104 are arranged side by side, with columns 108 parallel to each other, as shown in Fig 2. And the arrays 107 of patches 114 are thus vertically polarised. The E-plane thus coincides with

the vertical plane and the H-plane with the horizontal in this case. This is advantageous because it will provide a considerably better isolation between transmit antenna 102 and receive antenna 104, in comparison to if they were arranged side by side and fed as to be horizontally polarized. A large signal isolation between the transmit antenna 102 and receive antenna 104, is desired.

In another embodiment, not shown in Fig. 2, the transmit antenna 102 and the receive antenna 104 are arranged vertically in line with each other.

In yet another embodiment, not shown in Fig. 2, the transmit antenna 102 and the receive antenna 104 are arranged horizontally in line with each other. The polarisation will be horizontal in this case.

In yet another embodiment, the arrangement in Fig. 2 is rotated 90 degrees, so that the arrays are still arranged in parallel but with one now on top of the other. The polarisation will be horizontal in this case.

Fig. 3 shows a transmit antenna 102 and a receive antenna 104, including arrays 107 and sub arrays 109. Electronics 106 feed power splitters 112 and 113 via feed lines 117 and 118. The power splitters 112 and 113 feed the antennas, via microstrip lines 116 and 119. Further Fig. 3 shows metal frames 408 arranged around the antennas 102 and 104.

An embodiment of a transmit antenna 102 and a receive antenna 104 is shown, where each sub array 109 in the arrays 107 include a central feed via two separate parallel, with respect to λ_0, rather closely spaced, transmit microstrip lines 116 and 119, connected to a common power splitter 112 and 113. According to this embodiment, the distance between the parallel feed lines is around $\lambda_0/10$, which is considered closely spaced with respect to λ_0.

The lengths of the two transmit microstrip lines 116 and 119 differ half a guide wavelength seen from the power splitters 112 and 113 to the antennas 102 and 104, in order for the sub arrays 109 of the arrays 107 to radiate in phase in a direction normal to the PCB. The feed lines 117 and 118 may have a lower impedance on the electronics 106 side of the power splitter 112, than the microstrip lines 116 and 119 on the antennas 102 and 104 sides of the power splitters 112 and 113. By example the feed line 117 and 118 on the electronics 106 side may have 50 Ohm. And the microstrip lines 116 and 119 on the on the antennas 102 and 104 side may have 80 Ohm, with the appropriate impedance transformer integrated in the power splitter 112 and 113.

When feeding lines are divided, it is in general desired to have higher impedance on the side with the multiple of lines.

The arrangement with closely spaced receive microstrip lines 116 and 119 fed 180 degrees out of phase is favourable because it reduces stray radiation.

The impedance values on both sides of the power splitter 112 and the junction 113 should only be seen as examples. It should be understood that other values may be selected depending on preferred system impedance, permittivity, and height of PCB substrate.

In another embodiment the distance between the two microstrip lines 116 and 119 is $\lambda_0/4$, or $\lambda_0/20$, or a value between $\lambda_0/4$ and $\lambda_0/20$.

In an embodiment the distance between a ground plane in the PCB 100 and the transmit microstrip lines 116 is shorter, than the distance between the two parallel transmit microstrip lines 116. And the distance between a ground plane in the PCB 100 and the receive microstrip lines 119 is shorter, than the distance between the two parallel receive microstrip lines 119.

As shown in Fig. 3, the power splitters 112 and 113 are located outside the antenna 102 and 104 cavities and may be surrounded by shielding and lossy side walls 510 and roof 514 (further described in Fig.4) as the rest of the electronics 106. Beneath the side walls 510 metal frames 408 are arranged on the PCB 100. Metal frames 408 are surrounding the transmit antenna 102 and the receive antenna 104. The sidewalls 510 and metal frames 408 are physically and electrically connected in such a way that together they form walls around the antennas 102 and 104. The walls enclose the antennas 102 and 104, and the walls and the roof 514 together enclose the electronics 106.

In an embodiment, the metal frames 408 may be implemented by a metal foil and closely spaced metallic posts, e.g. via holes, which also are connecting the metal foil formed around the antennas (102, 104), with the ground plane (not shown in Figures). Via holes are advantageously closely spaced together relative to the wavelength, in order to shield radiation. For simplicity the term “power splitter” 112 may be used both for the function to split the feed from electronics 106 to the transmit antenna 102, as well as the function to merge the feeds from the receive antenna 104 to the electronics 106. Another term for the power splitter located between the receive antenna 104 and the electronics 106, is junction 113.

In an embodiment, as shown in Fig. 3, the receive antenna 104 includes two columns.

It is possible to show that the stray radiation for a 2D, two dimensional, case is reduced by a factor $O(a/\rho)$ for the two parallel microstrip line feed solution where "a" is the distance between the parallel lines, "ρ" is the orthogonal distance to the field point and "*O*" is the "large ordo symbol" used in mathematics .

The arrangement has at least the following advantages:

- The two parallel out of phase microstrip lines 116 and 119 cause less stray radiation by an order of magnitude than a single microstrip line feed.
- The two centrally fed sub arrays 109 of patches may be closely spaced.
- The power splitter 112 and 113 may be located outside the transmit antenna 102 cavity and isolated in order not to receive or contribute with stray radiation.

Fig. 4 shows the PCB 100, already described, for a radar system 50 with the antennas 102 and 104 surrounded by metal frames 408. Fig. 4 also shows inner cover 516, including side walls 510, inner walls 512, roof 514 and cavities 518 for power splitters 112 and 113, from a perspective view.

Side walls 510, inner walls 512 and roof 514 may collectively be described as inner cover 516. In an embodiment the side walls 510, inner walls 512 and roof 514 is formed in one single unit. The inner cover 516 is also described as conductive covering 516. The PCB 100 is shown with the antennas facing upwards, and the inner cover 516 is shown with the inside facing upwards. For the sake of clarity of the figures, entire metal frames 408 and inner cover 516 complete structures, is not shown. By example metal frames 408 and inner cover 516 shown in Fig. 4 surrounding power splitter 112 and 113, is not shown in Fig. 3 because it would make Fig 3 difficult to read.

In an embodiment, the power splitter 112 and junctions 113 are each located in separate cavities 518 formed by the PCB 100 and the inner walls 512 and the roof 514.

An advantage with the power splitters 112 and 113 located in separate cavities 518, is that stray radiation from the single feed line 117 and the power splitter 112 and junctions 113 may be isolated. Thereby stray radiation will be at a low level because of the two closely spaced microstrip lines 116 and 119, 180 degrees out of phase leaving/entering a power splitter.

In an embodiment shown in Fig. 4, the transmit antenna 102 and the receive antenna 104, are enclosed by side walls 510. The side walls 510 may shield the electronics 106 from stray radiation of the antennas.

In an embodiment the side walls 510 are both electrically conductive and provide attenuation of electromagnetic waves. There are a number of materials which can provide such characteristics, including: metals, plastics, or combinations thereof. An optimal balance is desired of electrical conductivity which shield electromagnetic waves, and attenuation which absorb the electromagnetic waves.

In an embodiment, the inner cover 516 may comprise metalized plastic fibres, with a coal suspension added to it.

In an embodiment for widening the antenna beam for each column with respect to H-plane, Fig. 4 shows vertically oriented conducting side walls 510 placed adjacent to the patch array. The side walls 510, parallel with columns 108, form a so called parallel plate waveguide. The parallel plate waveguide transforms the radiating aperture and phase centre away from the patches 114 surface to the waveguide aperture. In the case of an array 107 comprising one column with side walls 510 spaced between $\lambda_0/2$ and λ_0, a sinus shaped field taper will be created with respect to the horizontal direction, coinciding with the H-plane. This will happen provided the side walls 510 on the long side are high enough giving the possibility of a beam wide enough for a particular application.

The side walls 510 may in an embodiment be arranged separately around the antennas 102 and 104, and thereby provide the described advantageous features.

Fig. 5A shows a PCB 100 seen from the side, comprising a transmit antenna 102, a receive antenna 104. Fig. 5A also shows a transmit lens 604 and a receive lens 610.

According to Fig. 5A, the transmit lens 604 is arranged on top of the transmit antenna 102, with the PCB 100 surface upwards. I.e. radiation transmitted from the patches 114 is radiated through the transmit lens 604, on the way from the transmit antenna 102. According to the figure, the transmit lens 604 widens the transmit antenna 102 beam with respect to the H-plane. By arrangement of the transmit lens 604 in front of the transmit antenna 102, the antenna beam is refracted to a wider beam. This is advantageous for a short range wide coverage radar system 50.

According to Fig. 5A each column of the receive antenna 104, has its own receive lens 610, which individually widens the pattern of its corresponding column with respect to the H-plane. The receive lens 610 is arranged on top of the receive antenna 104,

with the PCB 100 surface upwards. I.e. radiation received to the patches 114 is passed through the receive lens 610, on the way to the receive antenna 104.

According to the figure, the receive lens 610 widens the receive antenna 104 beam with respect to each column in the H-plane. By arrangement of the receive lens 610 in front the receive antenna 104, the antenna beam corresponding to each column is refracted to a wider beam with respect to H-plane. This is advantageous because a receive antenna 104 can then operate in a wide coverage radar system 50.

In an embodiment, the transmit lens 604 and the receive lens 610 may be shaped as concave cylindrical lenses. The transmit lens 604 is arranged to broaden the transmit antenna 102 radiation pattern with respect to the H-plane. The H-plane coincides with the horizontal plane in this case, which is advantageous for a wide coverage short range radar system 50. In the near field of an aperture antenna, the energy flow is virtually orthogonal to the aperture, in this solution the patches 114 surface. The transmit lens 604 may refract the rays in such a way that the energy seems to emanate from a point above the surface of the patches 114. The transmit lens 604 may thereby move the phase centre of each sub array away from the patches 114 surface in the direction of the beam. Moreover the beam may be widened. A wide beam is desired, and thereby advantageous for a short rage wide coverage radar system 50.

The receive lens 610 may widen the radiation pattern received by each column of the receive antenna 104 with respect to the H-plane. Thereby the received beam may be widened in the H-plane with respect to each column. The H-plane coincides with the horizontal plane in this case, which is advantageous for a wide coverage short range radar system 50. In the near field of an aperture antenna, the energy flow is virtually orthogonal to the aperture, in this solution the patches 114 surface. The receive lens 610 may refract the rays in such a way that the energy seems to emanate from a point above the surface of the patches 114. The receive lens 610 may thereby move the phase centre of each sub array 109 away from the patches 114 surface in the direction of the beam. Moreover the beam may be widened.

A wide received beam for each column 108 is desired, and thereby advantageous for a short rage wide coverage radar system 50.

Fig. 5B shows a radar system 50, including the inner cover 516 shown in Fig. 4. Also PCB 100 with transmit antenna 102 and receive antenna 104, previously shown. And

radome 702 with transmit lens 604 and receive lens 610. The different parts in Fig. 5B, are shown with some distance apart.

According to Fig. 5B the radome 702 is arranged for its normal purpose, to cover the antennas and the electronics. The transmit lens and the receive lens, are in an embodiment, integrated in the radome 702.

An advantage of the radome 702 is to protect the antennas and electronics from unwanted physical effect, as well as possibly carrying a desired shape and colour.

In an embodiment, radome 702, the transmit lens 604, and the receive lens 610 are separate units, but essentially providing the same functionality as above.

In another embodiment, as shown in Fig 5B, a combination utilizes beam widening by the transmit lens 604, and the receive lens 610, and beam widening by the conducting side walls 510 creating parallel plate waveguide modes. The conducting side walls 510, transmit lens 604 and receive lens 610 may well be used separately, but used together they will cooperate for a better effect of a wide antenna beam with respect to the H-plane for each column.

In yet another embodiment, this combination effect of side walls 510 and the receive lens 610 is only utilized in the receive antenna 104, while the transmit antenna 102 obtains beam widening only by the transmit lens 604.

In yet another embodiment, the combination of side walls 510 and lens 604 is only utilized in the transmit antenna.

In an embodiment of a short range radar system 50, such a system typically has a coverage with respect to the horizontal plane with some 90° and with coverage of approximately 15° in elevation. Examples of other typical coverage's are; horizontal plane with some 45° and some 7° in elevation.

In an embodiment, the distance between the transmit antenna 102 and the receive antenna 104 is maximum 10 cm, or 50 cm.

In an embodiment the radar system 50 is operating on a frequency around 10 GHz, or 24 GHz, or 77 GHz, or in a range from 10 GHz to 77 GHz.

In an embodiment the radar system 50 is operating in a range of 0 to 200 meter, or 0 to 400 meter, or 0 to 800 meter.

CLAIMS

1. A printed circuit board (100) for a radar system (50) for short range detection of objects, comprising a microstrip patch array transmit antenna (102) arranged for transmission of radiation, a microstrip patch array receive antenna (104) arranged for reception of radiation and electronics (106) for radar and signal processing, where the electronics (106) are arranged for feeding to the transmit antenna (102), feeding from the receive antenna (104), and signal processing, wherein

the printed circuit board (100) comprises a metal frame (408) arranged around the transmit antenna (102) for isolation between transmit antenna(102), receive antenna (104) and electronics (106), and

the printed circuit board (100) comprises a metal frame (408) arranged around the receive antenna (104) for isolation between transmit antenna (102), receive antenna (104) and electronics (106).

2. The printed circuit board (100) according to claim 1, wherein

the transmit antenna (102) and the receive antenna (104) are fed centrally.

3. The printed circuit board (100) according to any of claims 1 or 2, wherein

each antenna (102, 104) is separated in at least two sub arrays (109), wherein

a power splitter (112) arranged to split the feeding to the transmit antenna (102) with a transmit feed line (117) connected to the electronics and two transmit microstrip lines (116) connected to the transmit antenna (102), wherein

the length of the two transmit microstrip lines (116) differ by half a guide wavelength λ_g such that a pair of two sub arrays (109) radiate in phase with respect to the normal direction of the printed circuit board (100).

4. The printed circuit board (100) according to any of claims 1 to 3, wherein

each antenna (102, 104) is separated in at least two sub arrays (109), wherein

a junction (113) arranged to merge the feeding from the receive antenna (104) with two receive microstrip lines (119) connected to the receive antenna (104) and a receive feed line (118) connected to the electronics, wherein

the length of the two receive microstrip lines (119) differ by half a guide wavelength λ_g such that a pair of two sub arrays (109) radiate in phase with respect to the normal direction of the printed circuit board (100).

5. The printed circuit board (100) according to any of claims 1 to 4, wherein

the two transmit microstrip feed lines (116) are closely spaced with respect to free space wavelength λ_0 for extinguishing of transmit microstrip feed lines (116) radiation, and

the two receive microstrip feed lines (119) are closely spaced with respect to free space wavelength λ_0 for extinguishing of receive microstrip feed lines (119) radiation.

6. The printed circuit board (100) according to any of claims 1 to 5, wherein

the patches (114) in a column (108) electrically have substantially the same distance between them.

7. The printed circuit board (100) according to any of claims 1 to 6, wherein

conductive side walls (510) are arranged around the receive antenna (104) to widen the beam from each column (108) with respect to the H-plane.

8. The printed circuit board (100) according to any of claims 1 to 7, wherein

patches (114) are connected in series and arrays (107) are individually adapted in size to successively decouple electromagnetic waves in such a way that substantially all energy is decoupled after the last patch (114) in an array (107).

9. A radar system (50) for short range detection of objects, comprising

a printed circuit board (100) according to any one of the claims 1 to 8, wherein

the radar system (50) comprises conductive side walls (510) arranged around the transmit antenna (102) cooperating with the metal frame (408), for isolation between transmit antenna (102), receive antenna (104) and electronics (106),

the radar system (50) comprises conductive side walls (510) arranged around the receive antenna (104) cooperating with the metal frame (408), for isolation between transmit antenna (102), receive antenna (104) and electronics (106).

10. The radar system (50) according to claim 9, wherein

the radar system (50) comprises a transmit lens (604) arranged in front of the transmit antenna (102) arranged to widen the transmit antenna (102) beam with respect to the H-plane, and

the radar system (50) comprises a receive lens (610) arranged in front of the receive antenna (104) arranged to widen the receive antenna (104) beam from each column (108) with respect to the H-plane.

11. The radar system (50) according to any of claims 9 or 10, further comprising

an inner cover (516) including said side and inner walls adapted to physically and electrically connect to the metal frame (408) in such a way that the walls and frame cooperates, and isolate between the electronics (106) and the antennas (102, 104).

12. The radar system (50) according to any of claims 9 to 11, wherein

the conductive covering (516) together with the metal frame (408) around the antennas (102, 104) forms the conductive side walls (510).

13. The radar system (50) according to any of claims 9 to 12, wherein

the transmit antenna (102) and the receive antenna (104) are arranged for concurrent transmission and reception.

14. The radar system (50) according to any of claims 9 to 13, wherein

the receive antenna (104) is arranged for reception of both amplitude and phase.

15. The radar system (50) according to any of claims 9 to 14, comprising;

a radar dome (702) for protection of the antennas (102, 104) and the electronics (106), and

the transmit lens (604) and the receive lens (610) integrated in the radar dome (702).

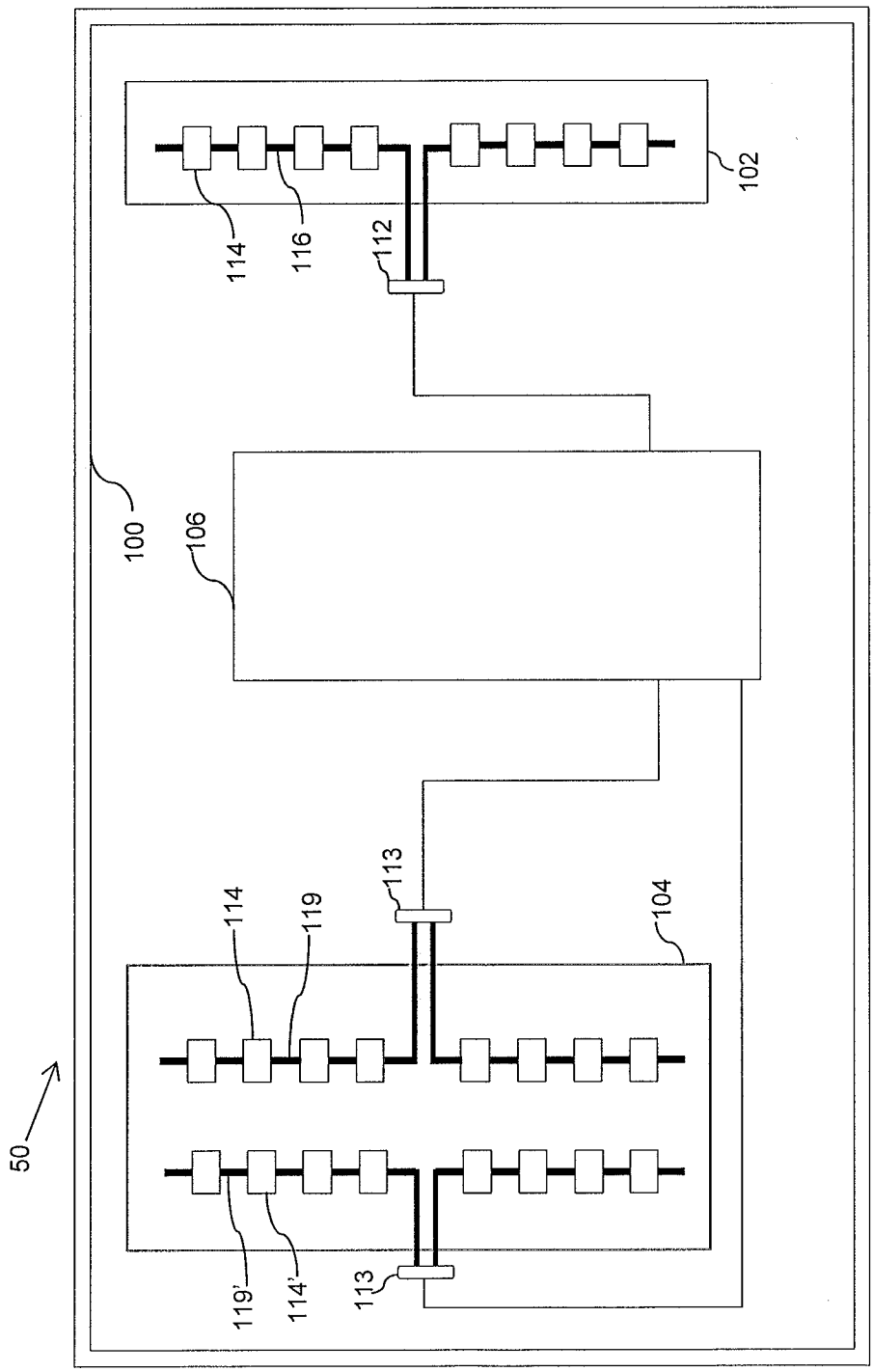


FIG. 1

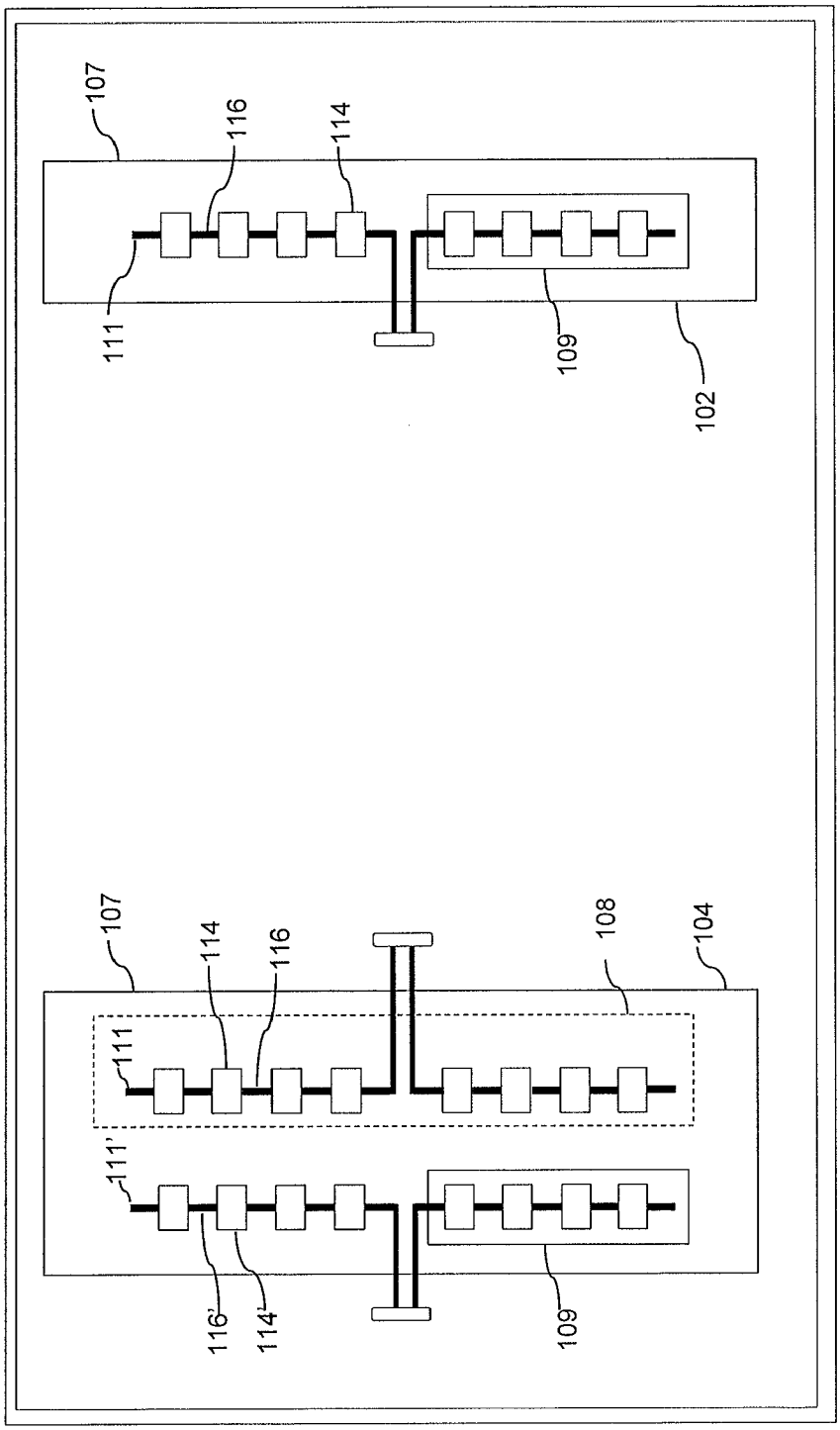


FIG. 2

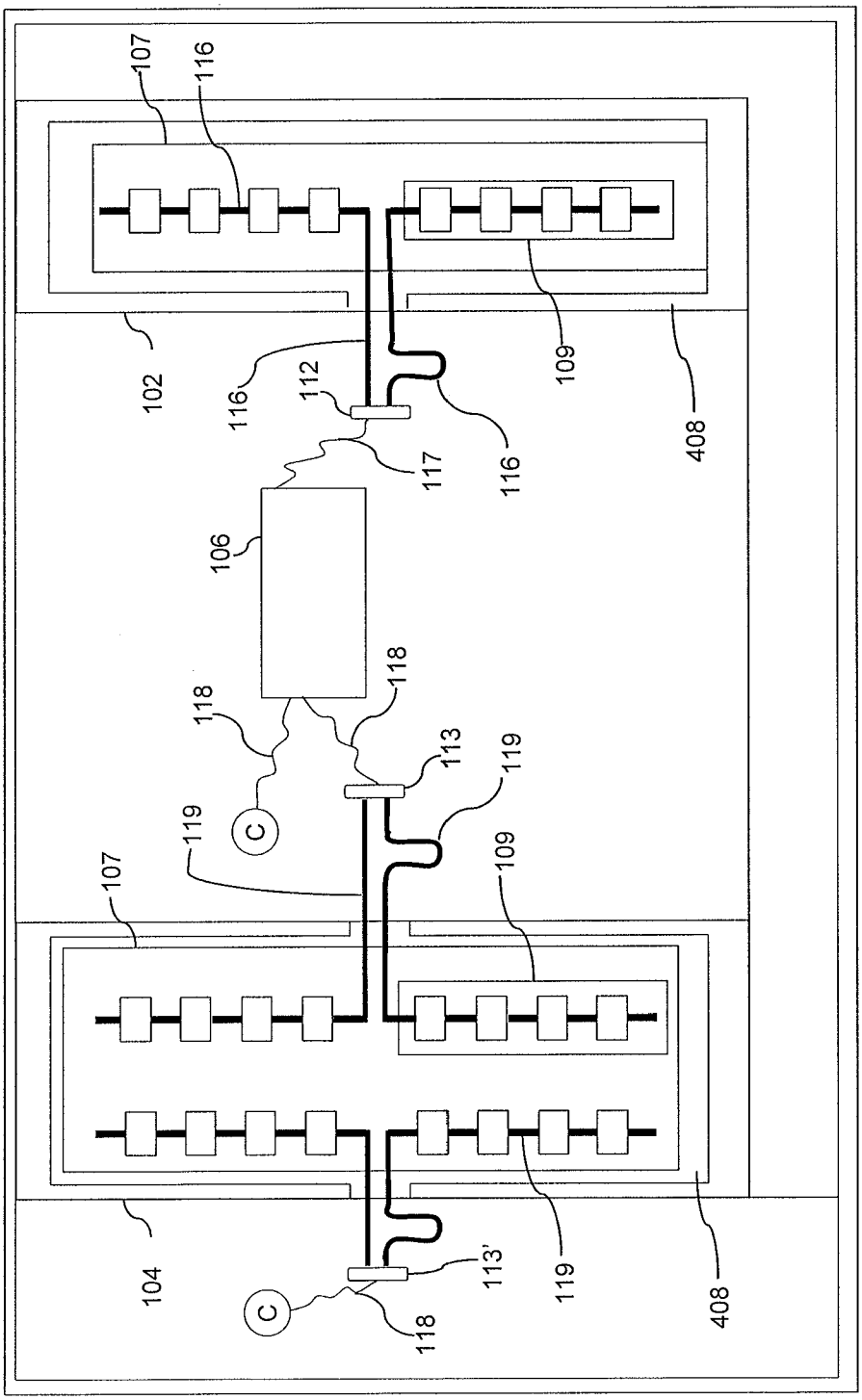

107
116
102
116
112
109
408
117
116
106
118
118
113
119
C
119
107
109
104
113'
119
C
118
408

FIG. 3

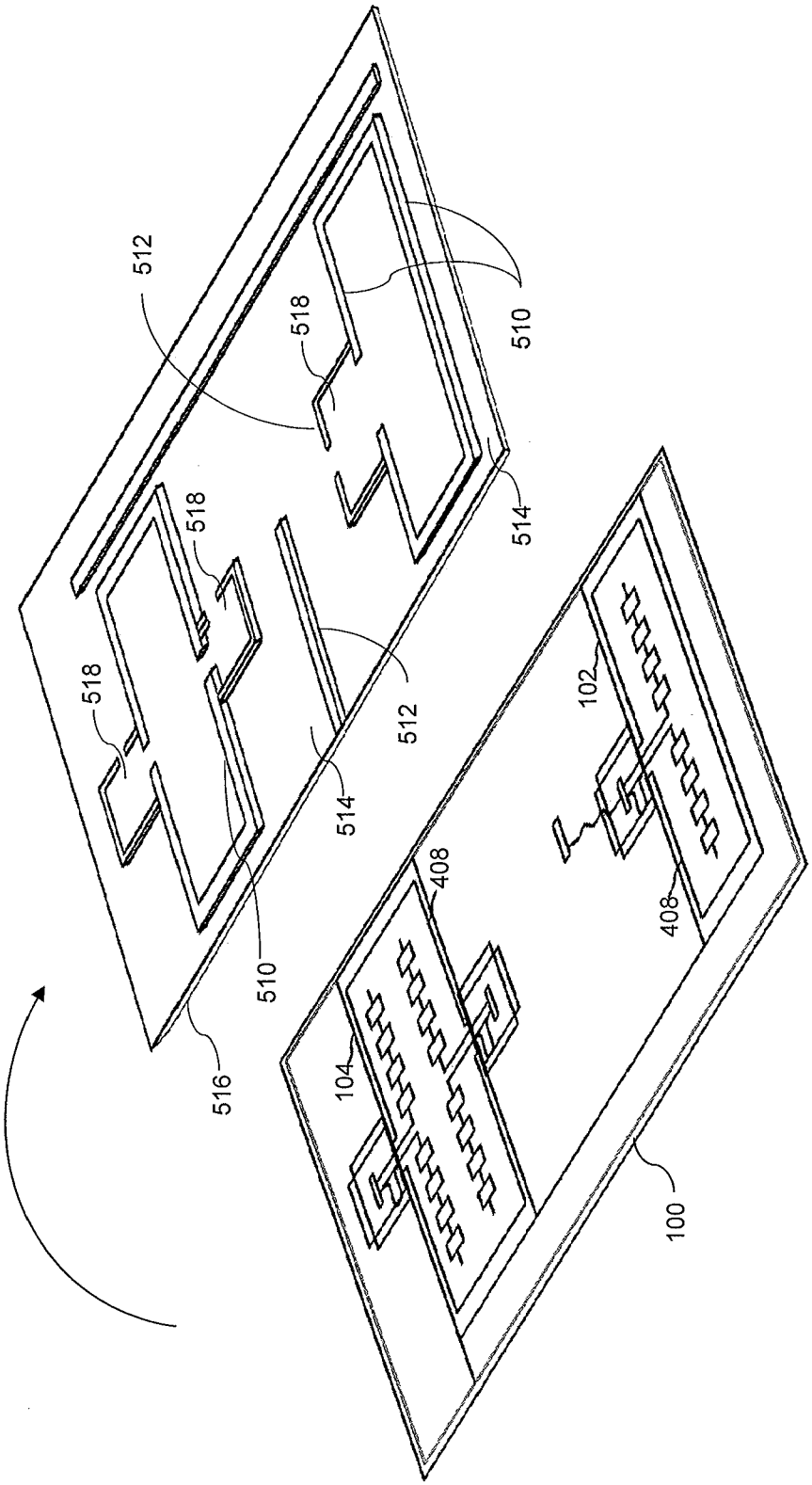


FIG. 4

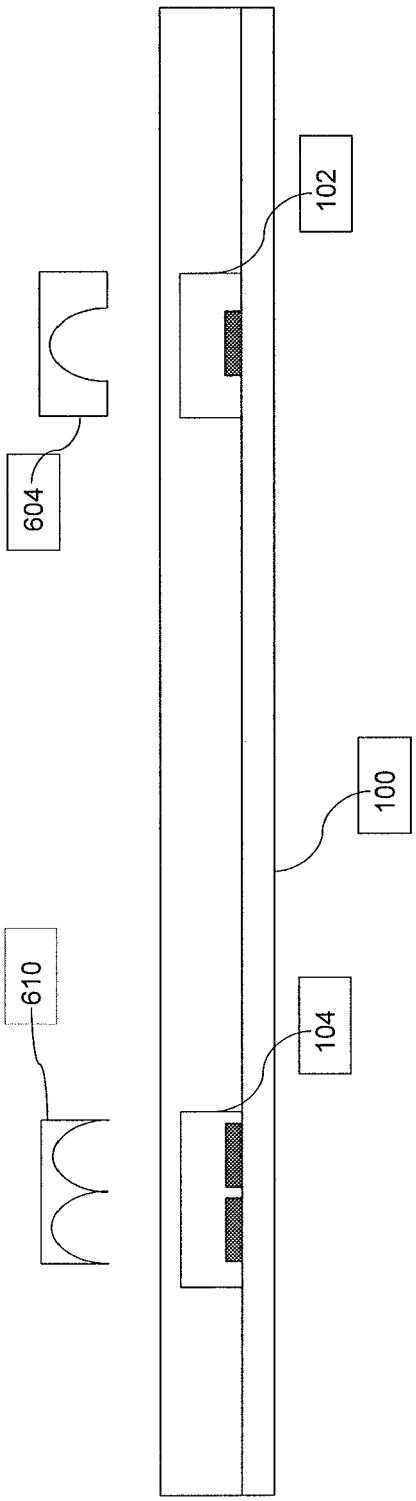


FIG. 5A

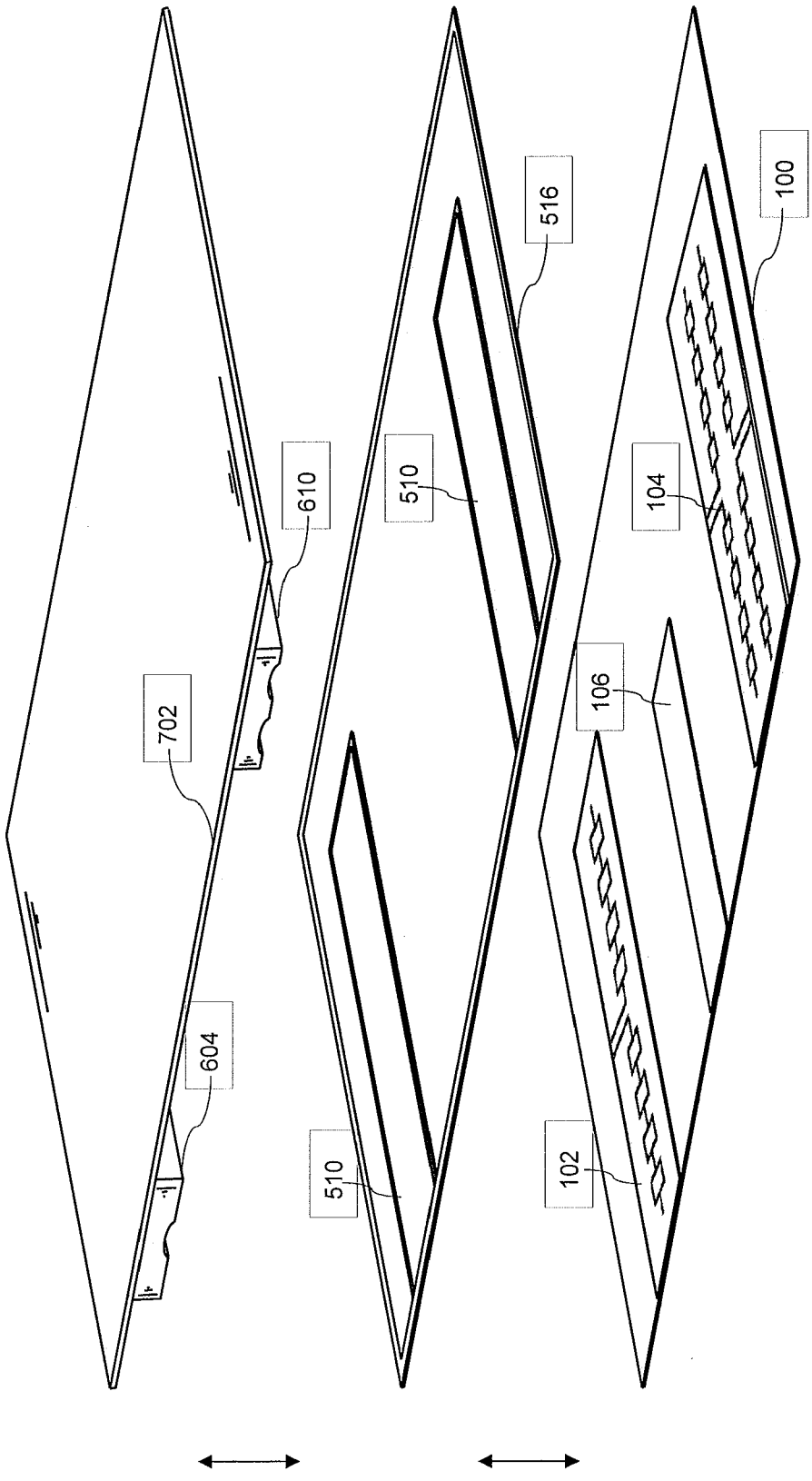


FIG. 5B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2011/051235

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: G01S, H01Q

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5495255 A (KOMATSU SATORU ET AL), 27 February 1996 (1996-02-27); abstract; column 2, line 11 - column 2, line 46; figures 1,2; claim 1	1, 9
A	--	2-8, 10-15
X	US 6861971 B2 (RUSSO PASQUALE ET AL), 25 November 2004 (2004-11-25); abstract; column 6, line 1 - column 6, line 9; figures 1,2	1, 9
A	--	2-8, 10-15

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
19-06-2012	20-06-2012

Name and mailing address of the ISA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Rune Bengtsson Telephone No. + 46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2011/051235

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5422649 A1 (HUANG JOHN), 6 June 1995 (1995-06-06); abstract; figure 2; cited in the application --	1-15
A	US 20090009399 A1 (GAUCHER BRIAN PAUL ET AL), 8 January 2009 (2009-01-08); abstract; figure 2a; cited in the application --	1-15
A	US 5977904 A (MIZUNO HIROSHI ET AL), 2 November 1999 (1999-11-02); column 3, line 45 - column 3, line 56; figures 1,5a,5b -- --------	10

International application No.
PCT/SE2011/051235

Continuation of: second sheet

International Patent Classification (IPC)

H01Q 9/04 (2006.01)
G01S 13/00 (2006.01)
H01Q 1/38 (2006.01)

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Cited literature, if any, will be enclosed in paper form.

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				EP	1417511	A2	12/05/2004
				IT	RM20010323	A1	09/12/2002
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				EP	0867972	A1	30/09/1998
				JP	3799724	B2	19/07/2006
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