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(54) Third resonance antenna

(57) The present invention relates to an antenna with a first antenna element (3) comprising a first and a second oblong portion (5, 6) arranged parallel and with a distance (W2) to each other. A transverse portion (7) connects said first and said second oblong portion (5, 6) at a distance (L2) from a feeding side end (9) of said first and second oblong portion (5, 6). A feeding portion 8 extends parallel to and between said first and said second oblong portion (5, 6) for connecting said transverse portion (7) with a transmission line. A reflector means (15, 24, 31, 36, 40, 43) is spaced to and parallel with a common plane of said first and said second oblong portion (5, 6). The proposed antenna is adapted for radiating at the third resonance and provides good matching capabilities in view of the antenna input impedance.

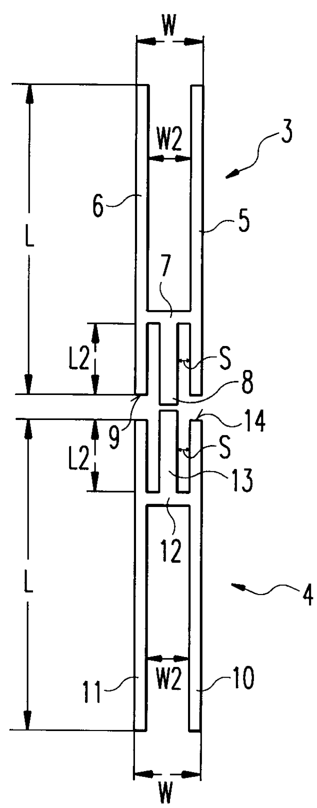

Fig. 2

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Description

[0001] The present invention relates to an antenna which is particularly adapted for radiating near or at the third resonance. The antenna comprises a reflector means, e.g. a reflector plate.

[0002] Printed dipole antennas with reflector plates are e.g. described in the US-patent no. 3587110, which discloses the idea of printed antenna structures over a reflector plane. The described dipoles radiate in first resonance.

[0003] In Fig. 1, an example for a known dipole antenna comprising two antenna elements is shown on the left side of the figure whereas the real and the imaginary part of the impedance of this dipole antenna is shown on the right side of the figure. The two dipole elements 1, 2 have an oblong shape and are arranged opposite to each other. In other words, the two antenna elements 1 and 2 are positioned on the same longitudinal axis in the same plane. The antenna elements 1 and 2 are fed at their respective ends, which are close to each other. Dipole antennas printed on a dielectric substrate with a reflection plate being arranged at a certain distance to said dielectric substrate have a number of advantages over conventional microstrip patch antennas. The main advantages are the wider bandwidth, lower loss and less parasitic radiation of the feeding or transmission lines. The distance between the reflection plate and the dielectric substrate is advantageously set to $\lambda/4$, whereby λ is the electric wave length of the central frequency within the material between the reflector plate and the dielectric substrate.

[0004] Up to now, printed dipole antennas radiating at the first resonance with an impedance near 50 Ohms have been used, as well as dipole antennas radiating at the second resonance, the impedances of which are of a magnitude of several hundred Ohms for a parallel connection in antenna arrays. The gain of dipole antennas radiating at the first resonance with a reflector plate arranged at a distance of $\lambda/4$ is about 7.5 dB and the gain of dipole antennas radiating at the second resonance is about 8 dB. However. dipole antennas radiating on the third resonance, due to their comparatively high electrical wavelength, have a gain of around 10 dB. The main drawback of classical dipole antennas working at the third resonance is the high voltage standing wave ratio (VSWR) which means that their input impedance usually does not match the usual system impedance of 50 Ohms. This case is shown in the diagram on the right side of Fig. 1, which shows the real and the imaginary part of such a dipole antenna having the shape shown on the left side of Fig. 1 and having a reflector plate at the distance of $\lambda/4$ to the antenna elements 1, 2. The diagram thereby shows the real and imaginary part in the vicinity of the third resonance. As can be seen in the diagram, when the value of the real part Re[Z] of the impedance Z is around 50 Ohms (at about 5.3 GHz), the imaginary part Im[Z] of the impedance Z has a negative value, i.e. it has a capacitance character. It becomes clear from Fig. 1 that in this case the input impedance is not ideal. The object of the present invention is therefore to provide an antenna radiating at the third resonance, the impedance of which can be matched easily to the impedance of the feeding system.

[0005] This object is achieved by an antenna according to claim 1, with a first antenna element comprising a first and a second oblong portion arranged parallel and with a distance to each other, a transverse portion connecting said first and said second oblong portion at a distance from a feeding side end of said first and second oblong portion and a feeding portion extending parallel to and between said first and said second oblong portion for connecting said transverse portion with a transmission line, and a reflector means spaced to and parallel with a common plane of said first and said second oblong portion.

[0006] The antenna according to the present invention is adopted to radiate at the third resonance, which means a larger gain compared to conventional antennas radiating at the first and the second resonance is provided. Simultaneously, the antenna according to the present invention has good matching capabilities. In other words, the antenna according to the present invention can easily be shaped to have an impedance close to the impedance of the feeding system. e.g. 50 Ohms. A further advantage of the antenna according to the present invention is the measured working band width of 10 % for a VSWR smaller than 2. Further, the antenna according to the present invention, when used as a dipole antenna, can be readily adapted for being arranged in antenna arrays, when a band width of 40-50 degrees in the E-plane is needed as well as in phase scanned arrays and smart antennas.

[0007] Advantageously, a second antenna element is arranged opposite to said first antenna element and comprises a first and a second oblong portion arranged parallel anti with a distance to each other. In other words. said second antenna element is positioned on the same longitudinal axis and in the same plane as said first antenna element. In said second antenna element. a transverse portion connects said first and second oblong portion at a distance from a feeding side end of said first and second oblong portion and a feeding portion extends parallel to and between said first and said second oblong portion for connecting said transverse portion with a transmission line. Said reflector means is commonly used for said first and said second antenna element and is spaced to and parallel with a common plane of said first and said second oblong portion of said second antenna element. The first antenna element and the second antenna element arranged opposite to each other operate as a dipole antenna. The reflector means advantageously is a reflector plate consisting of a metal material.

[0008] Advantageously, the distance L2 is smaller than L/2 whereby L is the length of the first and the second oblong portion. This means that the transverse portion is located closer to the feeding side end of the first and/or second antenna element than to the end opposite to said feeding side end.

[0009] Advantageously, a distance S between said feeding portion at said first and said second oblong portion is smaller than W2/2, respectively.

[0010] Further advantageous, a low loss substance is located between said first and/or said second antenna element and said reflector means, whereby the distance H between said first and/or said second antenna element and said reflector means is essentially $H = \lambda/4$, λ being the electric wavelength of the central frequency within the low loss substance.

[0011] Advantageously, said low loss substance is air. This means that no material is located between the first and/or second antenna element and the reflector means. Alternatively, said low loss substance can be a synthetic foam, e.g. polyurethane foam.

[0012] Advantageously, said first and/or said second antenna element consist(s) of thin metal plates, e.g. if the low loss substance is air. Alternatively, said first and/or said second antenna element consist(s) of thin metal films printed on a dielectric substrate. In this case, and if the antenna is a dipole antenna comprising a first and a second antenna element, the first and the second antenna element can be printed on the same face of said dielectric substrate. Alternatively, said first and said second antenna element can be printed onto opposite faces of said dielectric substrate. In case the antenna according to the present invention is a dipole antenna comprising a first and a second antenna element, the transmission lines can be balanced microstrip lines. In this case. the balanced microstrip lines can be coplanar to said first and to said second antenna element, respectively. Alternatively, said balanced microstrip lines can be essentially orthogonal to said first and said second antenna element. Further advantageously, a plurality of antennas comprising a first and a second antenna element can be arranged in an antenna array to be used as a diversity antenna, a phase scanned array or a smart antenna.

[0013] Advantageous embodiments of the present invention are explained below referring to the enclosed drawings, in which alike elements are designated with the same reference numerals, and in which

Fig. 1 shows the shape of a known dipole antenna and a diagram with the real and imaginary part of the impedance of such an antenna,

Fig. 2 shows an antenna according to the present invention being arranged as a dipole antenna,

Fig. 3 shows a diagram with the real and imaginary part of the impedance of the antenna shown in Fig. 2,

Fig. 4 shows a dipole antenna according to the present invention with orthogonal feeding,

Fig. 5 shows an antenna array of dipole antennas according to the present invention being arranged as a diversity antenna,

Fig. 6 shows an example for the use of dipole antennas according to the present invention,

Fig. 7 shows a diversity antenna comprising a plurality of dipole antennas according to the present invention in a side view,

Fig. 8 shows a top view of the antenna array shown in Fig. 7,

Fig. 9 shows an example for a monopole antenna according to the present invention comprising one antenna element,

Fig. 10 shows an example for a dipole antenna according to the present invention, wherein the antenna elements are printed onto the opposite side of a dielectric substrate,

Fig. 11 shows an example of a dipole antenna according to the present invention, in which the antenna elements are realized by metal plates,

Fig. 12 shows a diagram of the measured and predicted antenna gain of the dipole antenna shown in Fig. 4, and

Fig. 13 shows a diagram of calculated and measured values of the VSWR for one dipole antenna of the antenna array shown in Fig. 8.

[0014] Fig. 2 shows an example for an antenna according to the present invention. The shown antenna comprises a first antenna element 3 and a second antenna element 4 arranged opposite to each other on the same longitudinal axis and extending in a common plane. The shown antenna operates as a dipole antenna. The first antenna element comprises a first and a second oblong portion 5, 6. The first and the second oblong portion 5, 6 are arranged parallel and with a distance W2 to each other. The first and the second oblong portion 5, 6 thereby have the same length and the same width. A transverse portion 7 connects said first and said second oblong portion 5, 6 at a distance L2 from a feeding side and 9 of said first and said second oblong portion 5, 6. The feeding side end 9 of the first antenna element is the end of the antenna element on which the antenna element is fed. The first antenna element 3 further comprises a feeding portion 8 extending parallel to and between said first and said second oblong portion 5, 6. In other words, the feeding portion 8 is connected to said transverse portion 7 and extends parallel to and in a common plane with said first and said second oblong portion, whereby a respective slot is formed between said feeding portion 8 and said first and said second oblong portion 5, 6, respectively. The width of said slot or the distance between said feeding portion and said first and said second oblong portion 5, 6, respectively, has a value S. The value S is set to be smaller than W/2, whereby W is the entire width of the first antenna element. Further, the distance L2 between said transverse portion 7 and said feeding side end 9 is smaller than L/2 whereby L is the overall length of the first and the second oblong portion 5, 6.

[0015] The second antenna element 4 arranged opposite to said first antenna element 3 has exactly the same shape and measures as the first antenna element 3. Correspondingly. the second antenna element 4 comprises a first and a second oblong portion 10, 11 arranged parallel and with a distance W2 to each other. The first and the second oblong portion 10, 11 have the same length L. A transverse portion 12 connects said first and said second oblong portion 10, 11, at a distance L2 from a feeding side end 14 of said first and said second oblong portion 10, 11. A feeding portion 13 extends parallel to and between said first and said second oblong portion 10, 11. The width S of the slots between the feeding portion 13 and said first and said second oblong portion 10, 11, respectively, is smaller than W/2, whereby W is the width of said second antenna element. Further L2 is smaller than L/2 whereby L is the overall length of said first and said second oblong portion 10, 11.

[0016] By choosing the shape and the measures of the first and/or the second antenna element 3, 4 as shown in and described relating to Fig. 2, the real part Re[Z] of the input impedance Z of the antenna can be minimized so that a very good matching with the feeding system impedance can be achieved, which is shown in Fig. 3. By varying the dimensions of the first and/or the second antenna element 3, 4 it is possible to perform a fine tuning of the antenna impedance to the desired value.

[0017] In Fig. 3 a frequency diagram of the real part Re[Z] and the imaginary part Im[Z] of the input impedance Z of the antenna is shown for the dipole antenna shown in Fig. 2. Thereby, the impact of a reflection plate located at a distance of about $\lambda/4$ from the common plane of the antenna elements 3, 4 has been taken into consideration. For the diagram shown in Fig. 3. the shape of the dipole antenna shown in Fig. 2 has been optimized for a center transmission frequency of 5.2 GHz as can be seen from the frequency diagram in Fig. 1 which shows a dipole antenna impedance of about $Z=50+j\times 0$ Ohm for a center frequency of 5.2 GHz for the case that the dipole antenna radiates at the third resonance. Therefore, a very good matching to a transmission or feeding line impedance of about 50 Ohms is achieved.

[0018] In the following figures, the basic shape and measures of the shown antenna elements 3, 4 is essentially the same as the shape of the antenna elements 3, 4 shown in Fig. 2.

[0019] In Fig. 4 another example of a dipole antenna comprising a first antenna element 3 and a second antenna element 4 arranged opposite to each other is shown. The two antenna elements are printed onto the same side of a dielectric substrate 17. The dielectric substrate 17 is mounted onto a low loss material 16, which e.g. is a polyurethane foam. On the other side of the low loss material 16, a reflector plate 15 is located. The distance H between the reflector plate 15 and the dielectric substrate 17 on which the antenna elements 3, 4 are printed, is $\lambda/4$, whereby λ is the electric wavelength of the center frequency within the low loss material 16. Low loss means that the material 16 has a dielectric constant of about 1.

[0020] In the embodiment shown in Fig. 4 the first and the second antenna element 3, 4 are connected to and fed by microstrip lines 18. The microstrip lines 18 are printed onto a support plate 19. The microstrip lines 18 extend orthogonal to the common plane of the first and the second antenna element 3. The feeding side ends 9, 14, which are the ends of the first and the second antenna element 3, 4, which are close to each other, are connected to the microstrip lines 18. Within the low loss material 16 the microstrip lines 18 are balanced microstrips, which change into unbalanced microstrips in direction to the SMA connector 20.

[0021] Although orthogonal feeding of the antenna elements 3, 4 is shown in Fig. 4, a feeding in the same plane is possible. In this case, the microstrip lines 18 extend in the same plane as the first and the second antenna element 3, 4, whereby the first antenna element 3 and the second antenna element 4 are printed on opposite faces of the dielectric substrate 17.

[0022] In Fig. 5, an antenna 21 comprising a plurality of dipole antennas, each comprising a first and a second antenna element 3, 4 is shown. The shown antenna comprises four dipole antennas. Each dipole antenna comprises a first and a second antenna element 3, 4 and is arranged on a side face of a cube. The first and second antenna elements 3, 4 are printed onto a dielectric substrate 23 which is located on a low loss substance 22. Inside the antenna a square hole is formed, the side walls of which are formed by respective reflector plates 24. The distance H between each reflector plate on the inside of the cube and the corresponding dipole antenna is $\lambda/4$, whereby λ is the electric wavelength of the center frequency in the low loss substance 22. The longitudinal axis of the first and the second antenna element 3, 4 of each dipole antenna shown in Fig. 5 are parallel to each other and parallel to the middle axis of the through hole formed by the four reflector plates 24. The antenna 21 shown in Fig. 5 operates as a diversity antenna or as a smart antenna.

[0023] In Fig. 6 the use of a dipole antennas according to the present invention in a car 25 is shown. Four dipole antennas 26 each comprising a first and a second dipole element 3, 4 are integrated in the four corners of a car 25. Thereby, as shown by the antenna 26 at the right front corner of the car 25 in Fig. 6, the four antennas can be integrated into the bumpers 27 of the car. The longitudinal axis of the antenna 26 extends normally to the ground.

[0024] In Fig. 7 an example of an antenna array 28 comprising a plurality, e.g. 8 dipole antennas according to the present invention is shown. In the shown example, all dipole antennas each comprising a first and a second element 3, 4 are printed on the same face of a dielectric substrate 29 and are fed by balanced microstrip lines 33 extending orthogonally to the common plane of the dipole antennas. At a distance H from the dielectric substrate 29. a reflector plate 30 is located. Between the dielectric substrate and the reflector plate 30, a low loss substance 35 is arranged. The low loss substance 35 can be air or a low loss support material, e.g. polyurethane foam. The distance H is chosen to be $\lambda/4$ whereby λ is the electrical wavelength at the center frequency and the low loss substance. The microstrip feeding or transmission lines 34 are balanced within the low loss substance. Between the reflector plate and the SMA connectors 32 for connecting the antenna feeding lines 33 with further transmission means, a transmission from balanced to unbalanced microstrip lines takes place within the transmission lines 34. The SMA connectors 32 can be fixed to a support plate 31.

[0025] In Fig. 8, a top view of the antenna 28 shown in Fig. 7 is shown. Each of the 8 dipole antennas comprises a first and a second antenna element 3, 4. All the first and the second antenna elements 3, 4 are printed onto the same face of the dielectric substrate 29. All dipole antennas are arranged parallel and spaced to each other. The antenna array shown in Fig. 7 and 8 can be used as smart antenna, fixed phase antenna or adaptive phase antenna.

[0026] In the embodiments shown in Fig. 4 to 8 above, the antenna elements consist of thin metal films which are printed onto a dielectric substrate.

[0027] In Fig. 9, an antenna according to the present invention is shown, which consists of thin metal plates which are not printed onto any substrate and extend freely. The antenna shown in Fig. 9 is realized as a monopole antenna comprising only one antenna element 3. A reflector plate 36 is located at a distance H and parallel to the antenna element 3. The distance H is set to $H=\lambda/4$ whereby λ is the electric wavelength of the center frequency within air. In the embodiment shown in Fig. 9, the low loss substance is air. The antenna element 3 is mounted onto a support plane 37 extending orthogonal to the reflector plate 36. In an alternative embodiment, which is not shown, the antenna element 3 of the monopole antenna shown in Fig. 9 can also be printed onto a dielectric substrate, whereby the electric substrate can either be mounted onto a low loss substance, e.g. polyurethane foam, or extend freely.

[0028] In Fig. 10, a further embodiment of a dipole antenna comprising a first and a second antenna element 3, 4 according to the present invention is shown. In this embodiment, the first antenna element 3 is printed as a thin metal film onto an upper face of a dielectric substrate 38, whereas the second antenna element 4 is printed as thin metal film onto the lower face of the dielectric substrate 38. The dielectric substrate is located on a low loss substance 39, which can e.g. be polyurethane foam or air. At a distance H from the dielectric substrate 38. a reflector plane is positioned. The distance H thereby is set to $H=\lambda/4$ whereby λ is the electric wavelength at the center frequency in the low loss substance. In the embodiment shown in Fig. 10, the first and the second antenna element 3, 4 are fed by balanced microstrip lines, which extend in the same plane as the respective antenna element 3, 4.

[0029] In Fig. 11, another embodiment of a dipole antenna comprising a first and a second antenna element 3, 4 according to the present invention is shown. In this embodiment, the first and the second element consist of thin metal plates with a finite thickness, which extend freely. In this case, the low loss material located between the first and the second element 3, 4 and the reflector plate 43 is air. The reflector plate 43 is located at a distance H from the common plane of the first and the second antenna element 3, 4, whereby H is set to $H=\lambda/4$, whereby λ is the electric wavelength at the center frequency in air. In the embodiment shown in Fig. 11, the first and the second antenna element are fed by balanced metal strip lines 44, 45 extending orthogonal to the common plane of the first and the second antenna element 3, 4. The metal strip lines 44, 45 consist of metal with a finite thickness.

[0030] Fig. 12 shows the measured and the predicted antenna gain for the embodiment shown in Fig. 4. From the diagram it can be seen, that the maximum antenna gain is about 9.5 dBi, which means that the antenna according to the present invention radiating at the third resonance provides a much higher antenna gain than known antennas radiating at the first and the second resonance.

[0031] In Fig. 13, the calculated and measured values of the VSWR for one dipole antenna of the antenna array shown in Fig. 7 and 8 is shown. It can be seen, that one dipole antenna in the antenna array of Fig. 7 and 8 has an operation bandwidth of 8 % for a VSWR less than two.

[0032] In all embodiments shown in Fig. 3 to 11 of the present invention, the reflector plane or reflector plate consists of a metal material. Thereby, the reflector plate can either be printed as a thin metal film onto a corresponding substrate, or the reflector plate can consist of a metal film with a finite thickness.

Claims

1. Antenna, with
a first antenna element (3) comprising a first and a second oblong portion (5, 6) arranged parallel and with a distance W2 to each other, a transverse portion (7) connecting said first and said second oblong portion (5, 6) at a distance L2 from a feeding side end (9) of said first and second oblong portion (5, 6), and a feeding portion extending parallel to and between said first and said second oblong (5, 6) portion for connecting said transverse portion (7) with a transmission line, and a reflector means (15, 24, 31, 36, 40, 43) spaced to and parallel with a common plane of said first and said second oblong portion (5, 6).

2. Antenna according to claim 1,
characterized by
a second antenna element (4) arranged opposite to said first antenna element (3) and comprising a first and a second oblong portion (10, 11) arranged parallel and with a distance W2 to each other, a transverse portion (12) connecting said first and said second oblong portion (10, 11) at a distance L2 from a feeding side end (14) of said first and second oblong portion (10, 11), and a feeding portion (13) extending parallel to and between said first and said second oblong portion (10, 11) for connecting said transverse portion (12) with a transmission line, whereby said reflector means (15) is spaced to and parallel with a common plane of said first and said second oblong portion (10, 11) of said second antenna element (4).

3. Antenna according to claim 1 or 2,
characterized in,
that L2 is smaller than L/2, whereby L is the length of the first and the second oblong portion (5, 6; 10, 11).

4. Antenna according to claim 1, 2 or 3,
characterized in,
that a distance S between said feeding portion and said first and said second oblong portion (5, 6; 10, 11) is smaller than W/2, respectively.

5. Antenna according to one of the preceding claims,
characterized in,
that a low loss substance (16, 2, 35, 39) is located between said first and/or second antenna element (3, 4) and said reflector means and that the distance H between said first and/or said second antenna element and said reflector means is essentially $H = \lambda/4$, λ being the electric wavelength of the central frequency within the low loss substance.

6. Antenna according to one of the preceding claims,
characterized in,
that said low loss substance (35) is air.

7. Antenna according to one of the claims 1 to 6,
characterized in,
that said low loss substance (16, 22, 39) is a synthetic foam.

8. Antenna according to one of the preceding claims,
characterized in,
that said first and/or said second antenna element (5, 6; 10, 11) consist(s) of thin metal plates.

9. Antenna according to one of the claims 1 to 8,
characterized in,
that said first and/or said second antenna element (5, 6; 10, 11) consist(s) of thin metal films printed on a dielectric substrate (17, 23, 29, 38).

10. Antenna according to claim 9, if related back to claim 2,
characterized in,
that said first and said second antenna element (5, 6; 10, 11) are printed onto the same face of said dielectric substrate.

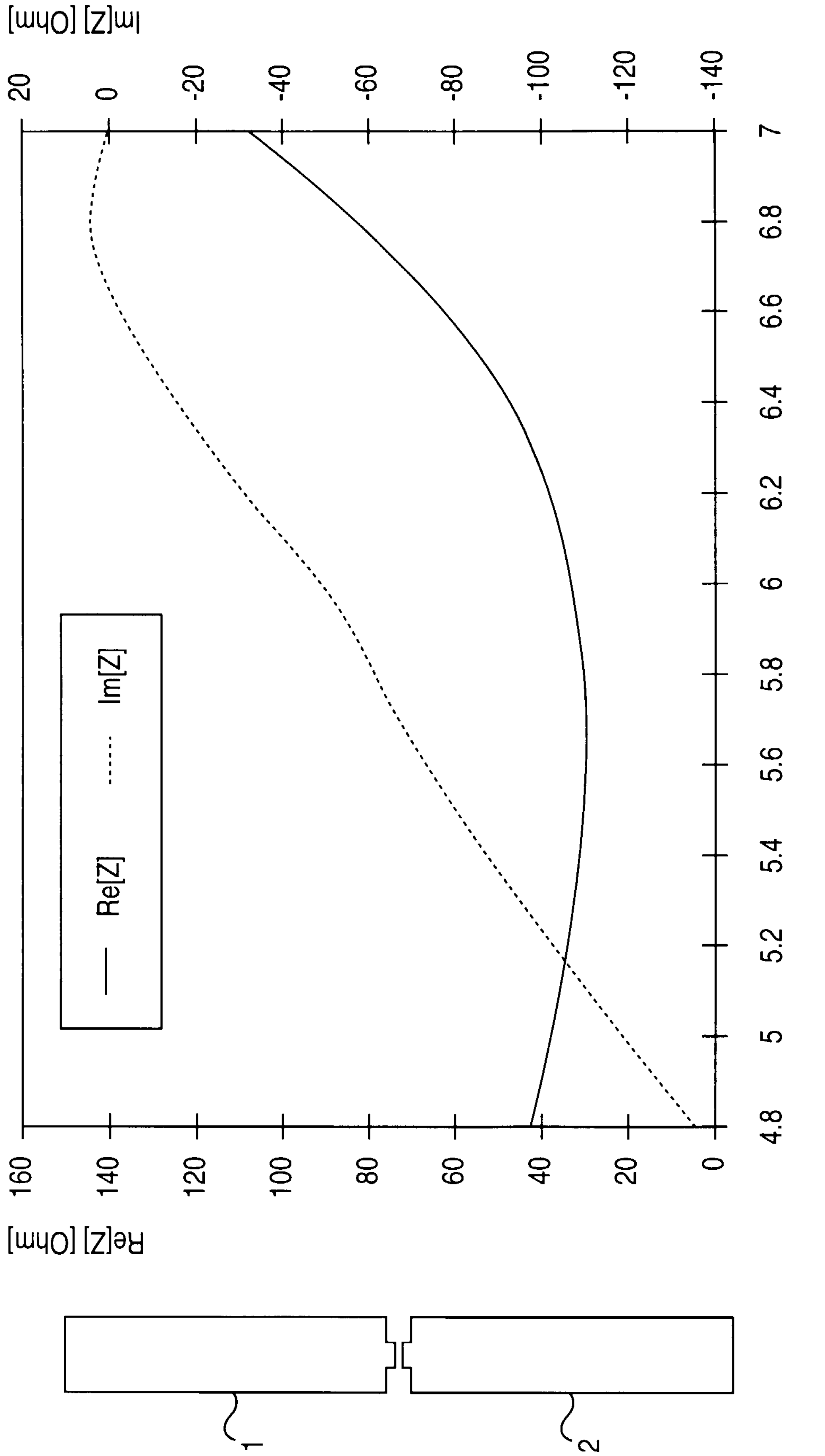
11. Antenna according to claim 9, if related back to claim 2,
characterized in,
that said first and said second antenna element (5, 6; 10, 11) are printed onto opposite faces of said dielectric substrate.

12. Antenna according to one of the claims 3 to 11, if related back to claim 2,
characterized in,
that said transmission lines are balanced microstrip lines.

13. Antenna according to claim 12,
characterized in,
that said balanced microstrip lines are coplanar to said first and said second antenna element (5, 6; 10, 11), respectively.

14. Antenna according to claim 12,
characterized in,
that said balanced microstrip lines are essentially orthogonal to said first and said second antenna element.

15. Antenna array comprising a plurality of antennas as defined in one of the claims 3 to 14, if related back to claim 2.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-20
-40
-60
-80
-100
-120
-140
Re[Z] [Ohm]
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100
80
60
40
20
0
4.8
5
5.2
5.4
5.6
5.8
6
6.2
6.4
6.6
6.8
7
f[GHz]
Re[Z]
Im[Z]
1
2

Fig. 1

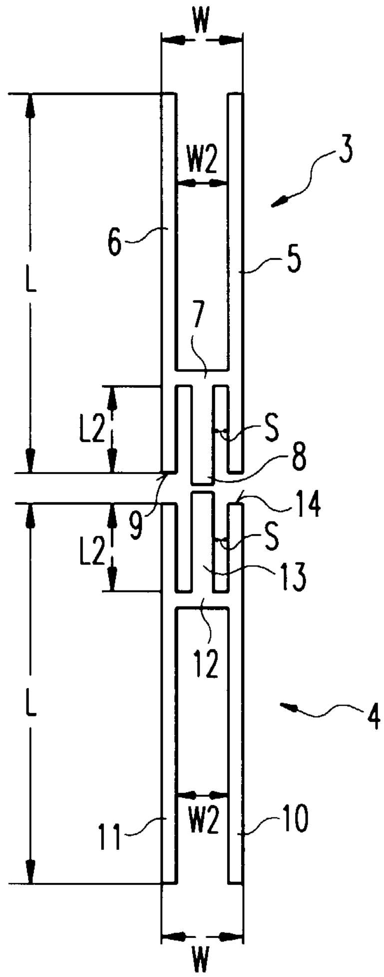
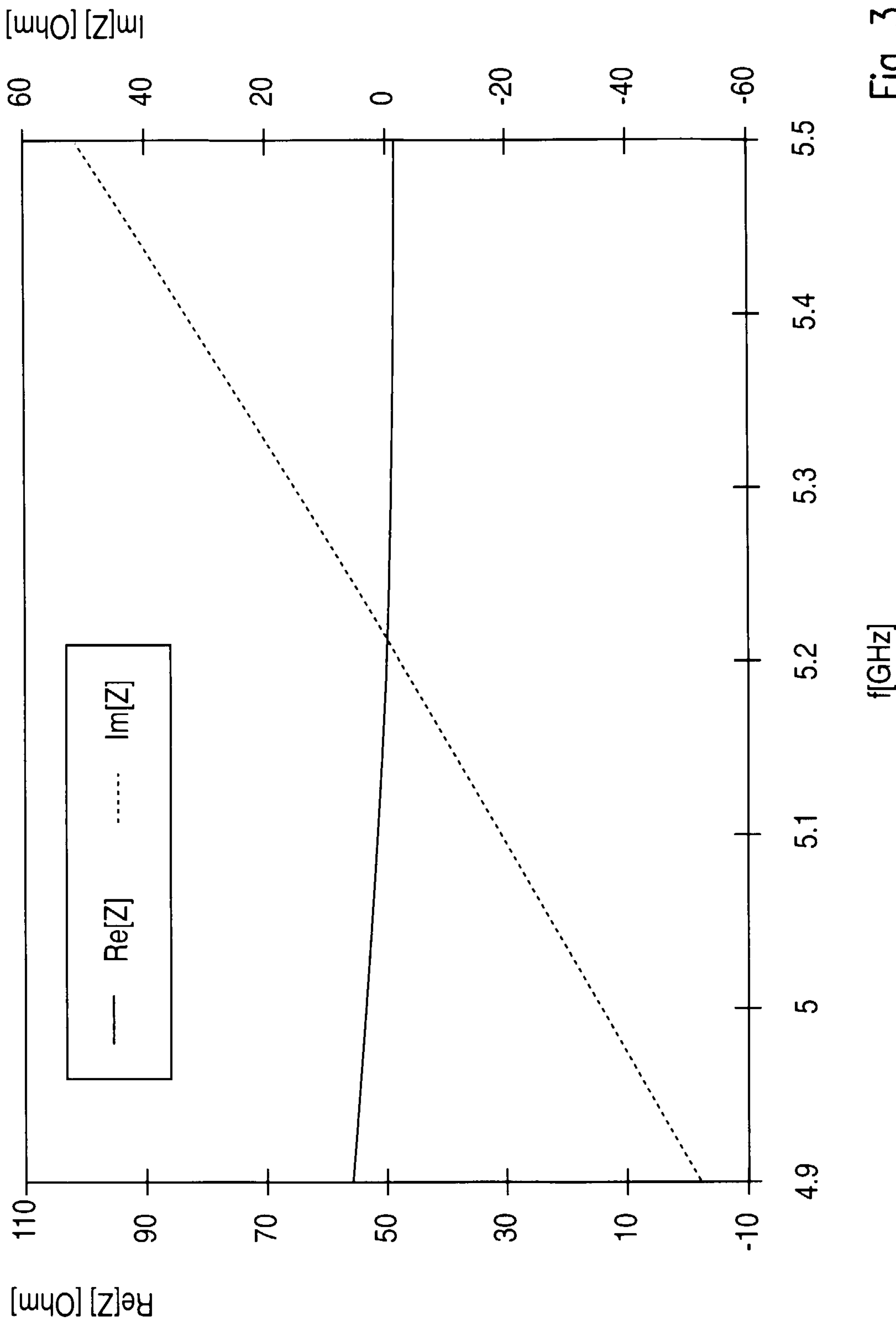


Fig. 2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70
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Fig. 3

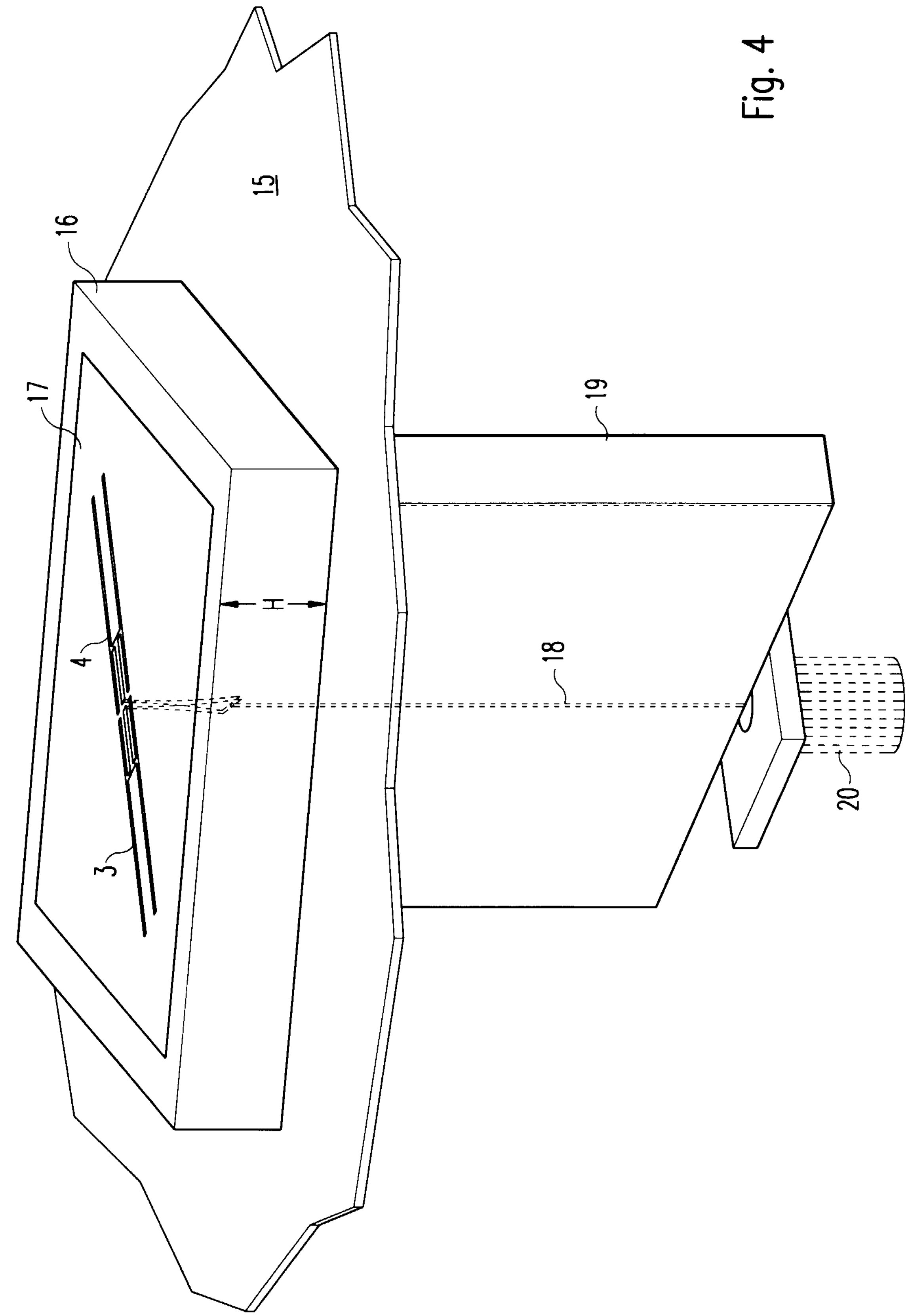
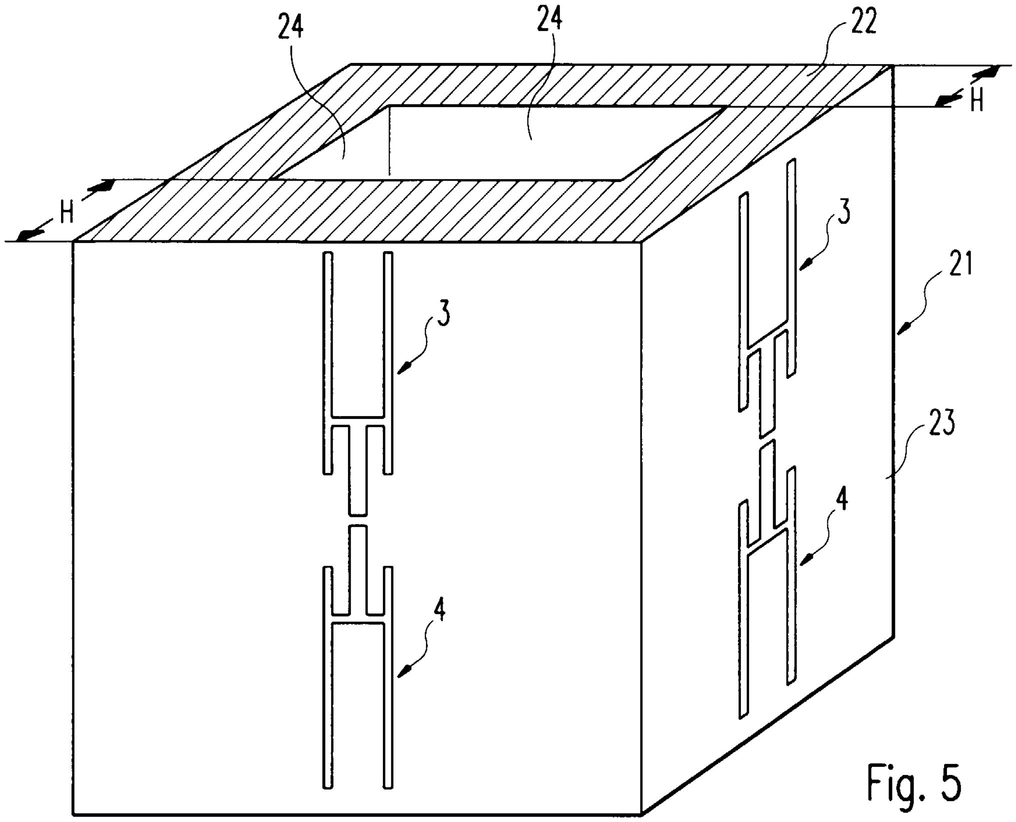


Fig. 4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23
4
4

Fig. 5

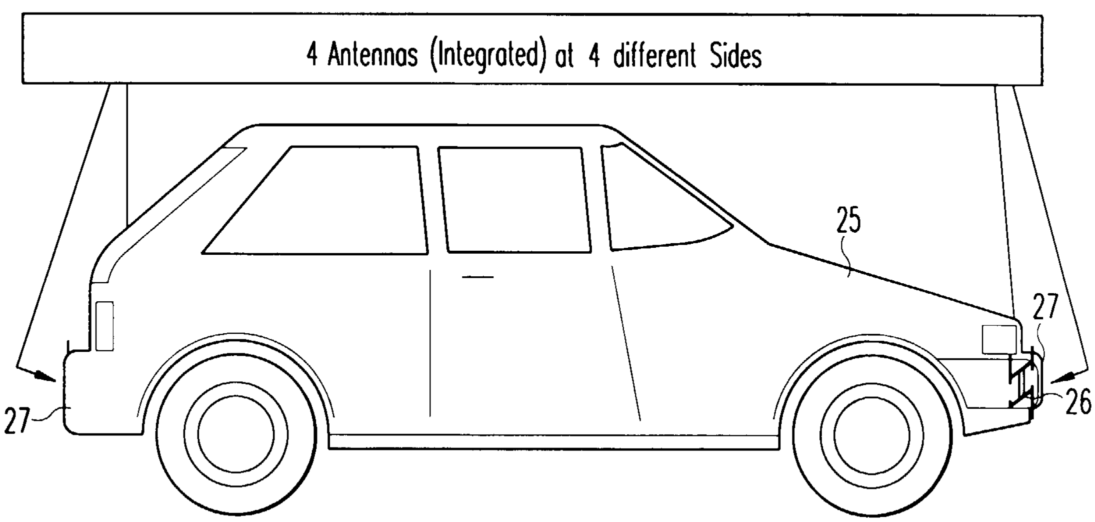
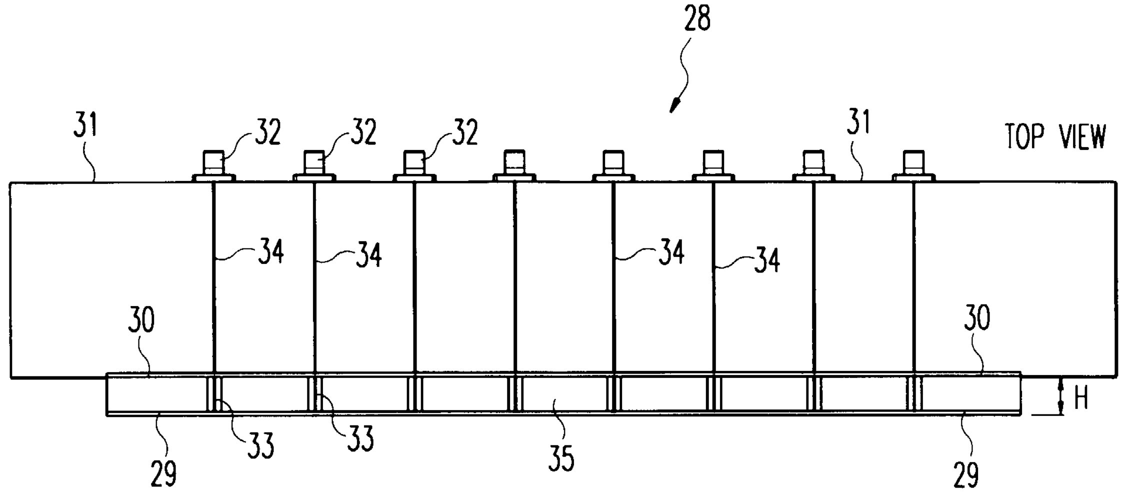

4 Antennas (Integrated) at 4 different Sides
25
27
27
26

Fig. 6


28
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TOP VIEW
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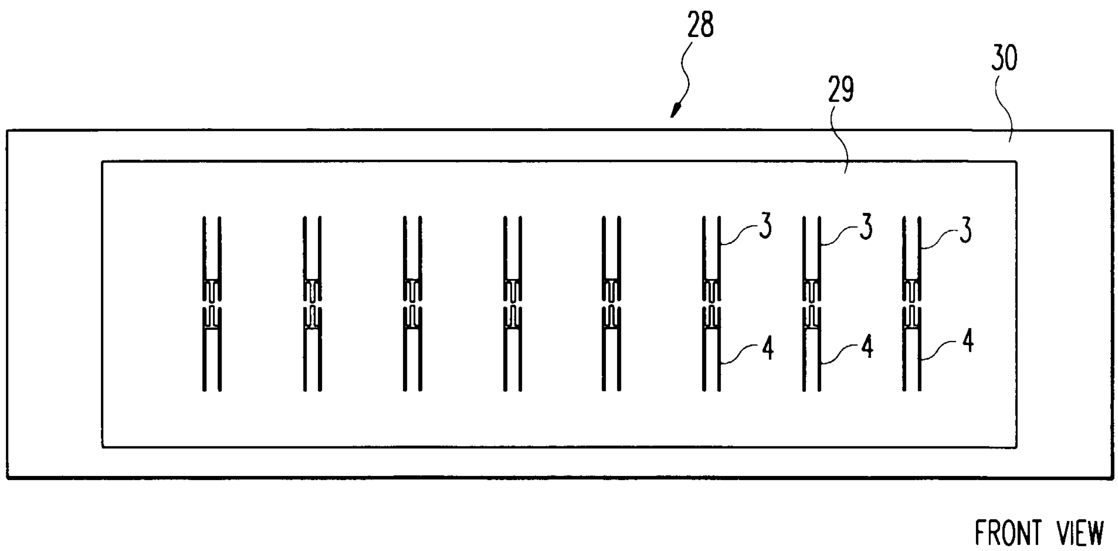
Fig. 7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FRONT VIEW

Fig. 8

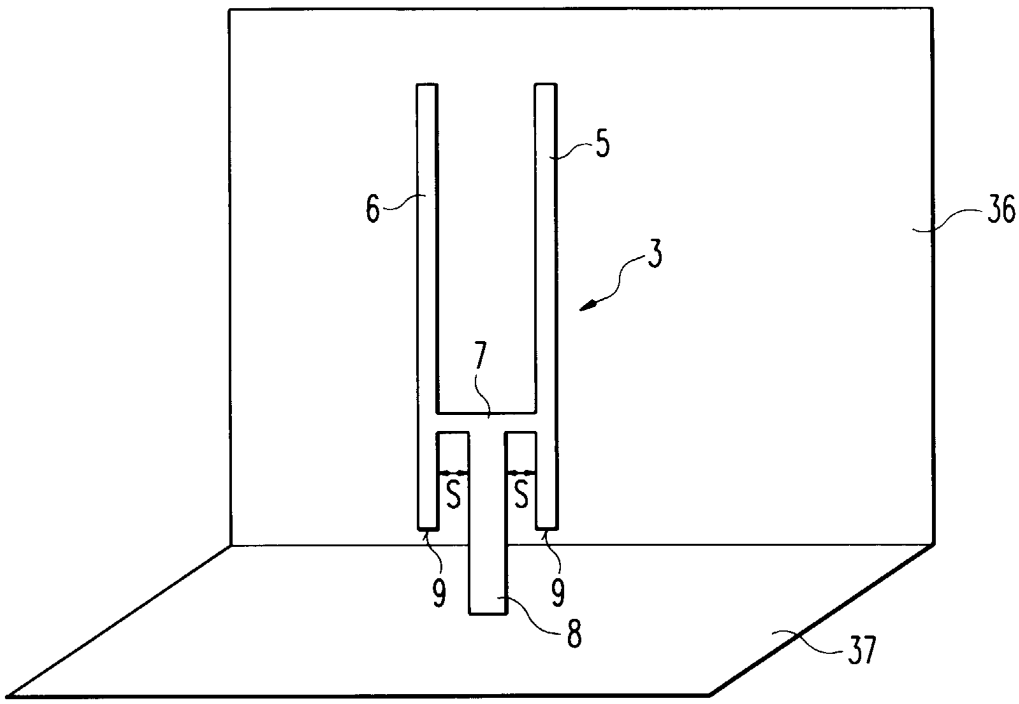

Fig. 9

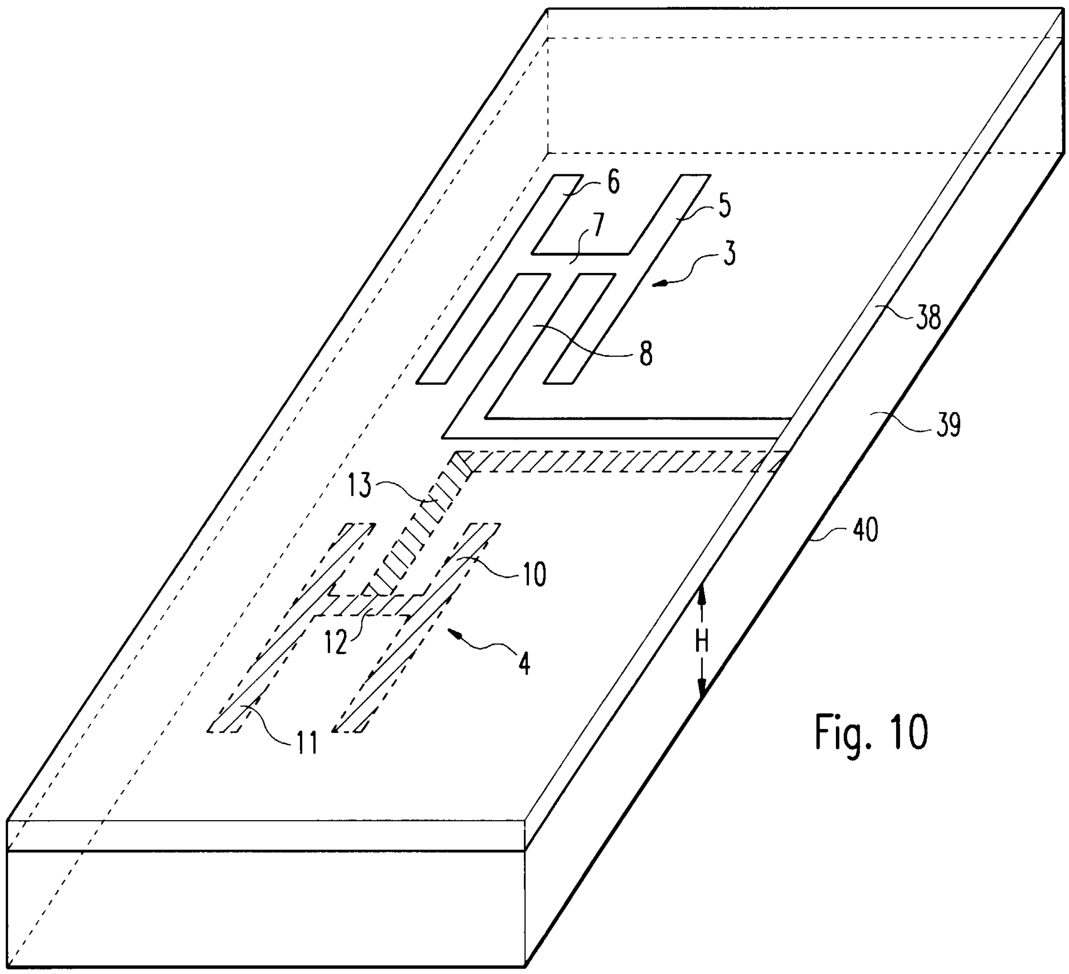

Fig. 10

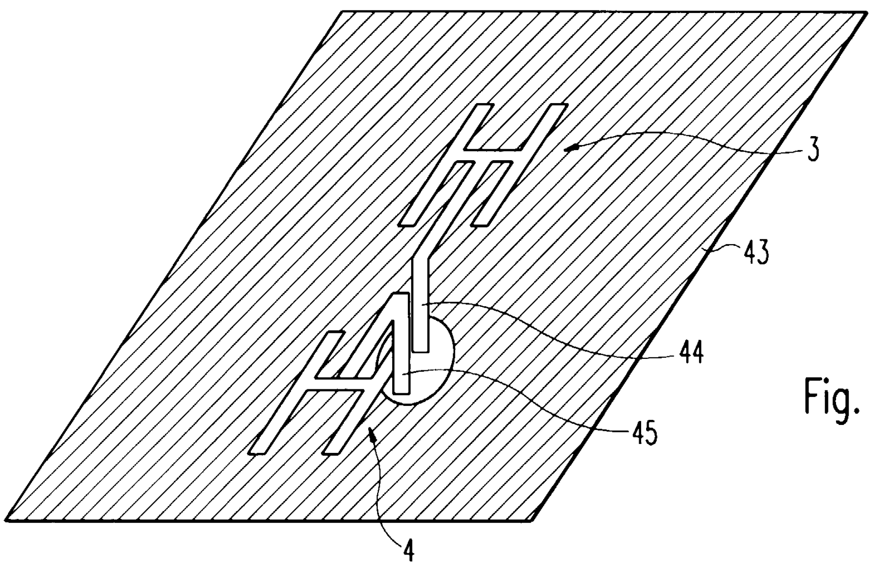

Fig. 11

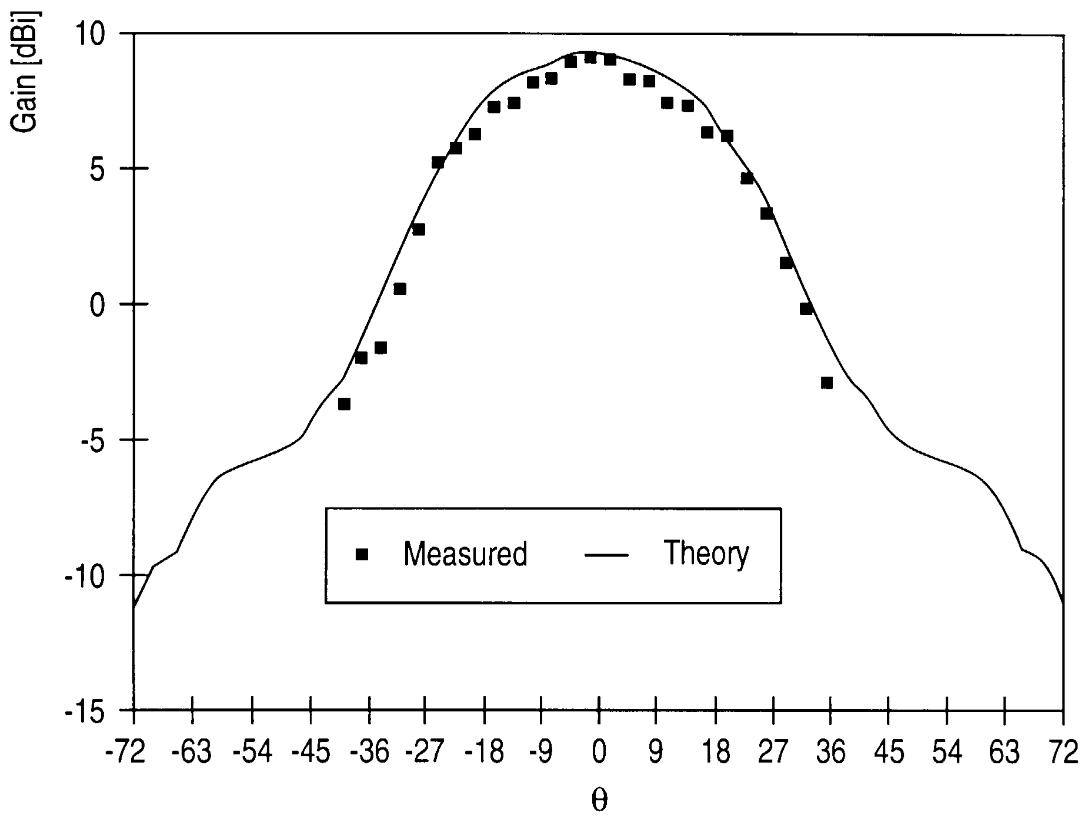
Gain [dBi]
10
5
0
-5
-10
-15
-72 -63 -54 -45 -36 -27 -18 -9 0 9 18 27 36 45 54 63 72
θ
Measured
Theory

Fig. 12

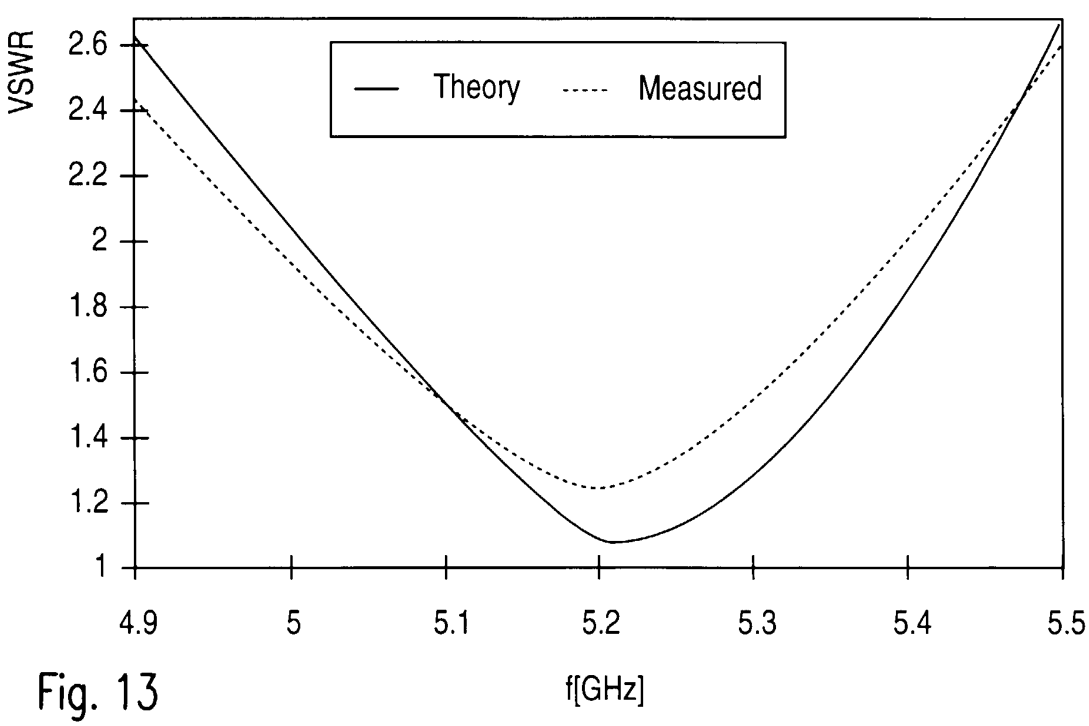
VSWR
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
4.9 5 5.1 5.2 5.3 5.4 5.5
f[GHz]
Theory
Measured

Fig. 13

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EUROPEAN SEARCH REPORT

Application Number
EP 98 11 1290

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	US 4 074 270 A (KALOI CYRIL M) 14 February 1978 * abstract; figure 1 *	1,2	H01Q9/06 H01Q9/28
Y	US 3 369 245 A (REA NORMAN J) 13 February 1968 * abstract; figure 3 *	1,2	
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D	& US 3 587 110 A		

-/--

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	27 November 1998	Breusing, J

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Application Number
EP 98 11 1290

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP 0 700 115 A (HOLLANDSE SIGNAALAPPARATEN BV) 6 March 1996 * column 2, line 24 - column 3, line 20; figure 2 * -----	1,2,5, 7-9	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)

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