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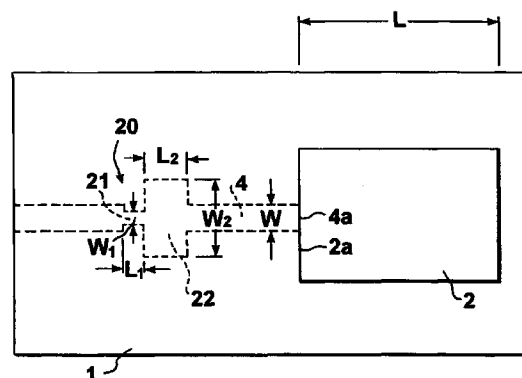
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(54) **Electromagnetically coupled microstrip antenna**

(57) For increased bandwidth an electromagnetically coupled microstrip antenna device comprises a first substrate 1; an antenna element 2 provided on a first surface 1a of the first substrate 1; a second substrate 2; and a feeding element 4 provided between a second surface 1b of the first substrate 1 and a first surface 3a of the second substrate 3; wherein an end portion 4a of the feeding element 4 is positioned within a range of $-0,3L$ and $+0,3L$ from an edge portion 2a of the antenna element 2, wherein L is the extension of the antenna element 2 in the direction of overlap between the antenna element 2 and the feeding element 4.

FIG.1



Description

[0001] The present invention relates to an electromagnetically coupled microstrip antenna.

[0002] Electromagnetically coupled microstrip antennas (also referred to as 'proximity-coupled' antennas) like microstrip antennas in general exhibit only a small bandwidth. Different attempts have been made to increase the bandwidth of microstrip antennas, including the use of thicker substrates, of parasitic elements and of impedance-matching networks.

[0003] In ELECTRONICS LETTERS, 9th April 1987, Vol.23, No.8, pp. 368-369 an electromagnetically coupled microstrip patch antenna is disclosed consisting of a rectangular microstrip patch on a first substrate and a microstrip feeding line on a second substrate beneath the first substrate. A ground plane is provided beneath the second substrate. The feeding line is centered with respect to the patch width and is inset half the patch length. A feeding line inset smaller and greater than half the patch length is mentioned but an inset equal to half the patch length is described to be advantageous for maximum coupling between the microstrip feeding line and the microstrip patch. To increase the bandwidth of the microstrip antenna a small tuning stub is provided which is connected in shunt with the microstrip feeding line and is located either near the edge of the microstrip patch or about $\lambda/2$ away.

[0004] In IEEE Trans. Antennas Propaga., Vol. AP-38, No. 7, pp. 1136-1140, July 1990, G.Splitt et al, 'Guidelines for Design of Electromagnetically Coupled Microstrip Patch Antennas on Two-Layer Substrates', a design rule is disclosed for determining the position of the end of a microstrip feeding line end under a square microstrip patch with reference to the center of the patch in a two layer structure. According to this design rule the end of the feeding line should be located at a distance of $\pm 0,2$ of the patch length from the center of the microstrip patch.

[0005] In M+RF 97, 30 September - 2 October 1997, London, UK, pp. 59-64, Ammann, Max J., 'A broadband proximity-coupled microstrip patch antenna for wireless LANs', the design and evaluation of a two layer electromagnetically coupled microstrip patch antenna is discussed. A microstrip antenna is disclosed consisting of a first substrate on which the square radiator is printed and a second substrate on which the feeding line is printed below the first substrate. To increase radiation efficiency and bandwidth of the radiator the first substrate is relatively thick and consists of a material having a low relative permittivity. To reduce radiation efficiency of the feeding line the second substrate is relatively thin and consists of a material having a high relative permittivity. The feeding line is centered with respect to the patch width. It is described that the patch overlap may be adjusted for best match and optimum impedance bandwidth. In the given example, the open end of the feeding line of the microstrip antenna overlaps the patch

by slightly more than half the patch length. The bandwidth is increased by providing a small matching stub positioned on the feeding line.

[0006] Although the bandwidth may be increased by using a stub positioned on the feeding line of an electromagnetically coupled microstrip antenna, the values achieved in the prior art are not sufficient for employing this kind of antennas in several applications, for example in a reception unit of Direct-To-Home (DTH) satellite reception antennas. These antennas are designed for the reception of direct broadcast signals and conventionally comprise a feedhorn and a LNB (Low Noise Block Converter) as, for example, disclosed in EP-A-0735 610. In order to avoid the transition from hollow waveguide technology, i.e. the feedhorn, to planar waveguide technology, i.e. the LNB, and the losses introduced thereby it is desirable that a microstrip antenna should be available which can be connected as a feed to the LNB of a reception apparatus capable of receiving directly broadcast signals.

[0007] A first problem of the present invention is to provide an electromagnetically coupled microstrip antenna exhibiting an increased bandwidth.

[0008] A second problem of the present invention is to provide an electromagnetically coupled microstrip antenna being capable of simultaneously receiving horizontally and vertically polarized waves.

[0009] A third problem of the present invention is to provide a reception apparatus capable of receiving directly broadcast signals and exhibiting reduced losses.

[0010] The above first problem is solved by providing an electromagnetically coupled microstrip antenna device comprising a first substrate; an antenna element provided on a first surface of the first substrate; a second substrate; and a first feeding element provided between a second surface of the first substrate and a first surface of the second substrate; wherein an end portion of the first feeding element is positioned within a range of $-0,3L$ and $+0,3L$ from an edge portion of the antenna element, wherein L is the extension of the antenna element in the direction of overlap between the antenna element and the feeding element.

[0011] According to an embodiment of the invention, a second feeding element is provided between the second surface of the first substrate and the first surface of the second substrate, an end portion of the second feeding element is positioned within a range of $-0,3L$ and $+0,3L$ from an edge portion of the antenna element, wherein L is the extension of said antenna element in a direction of overlap between the antenna element and the feeding element.

[0012] It is essential to realize that according to the invention no overlap between the antenna element and the feeding element is required. In contrast to prior art devices, an overlap-free arrangement is the basis for the design and evaluation of microstrip antennas suitable for different purposes. Therefore, a microstrip

antenna essentially free from overlap between the main antenna element and the feeding element or elements is the preferred embodiment.

[0013] Typically, said first and/or second feeding elements are elongated feeding lines. Further, said first and second feeding elements are usually arranged substantially perpendicularly to each other.

[0014] To match impedances, an impedance-matching means can be provided in a microstrip antenna according to the invention. Typically, impedance-matching means is an impedance-matching network connected to the first and/or second feeding element.

[0015] Advantageously, the first and/or second feeding element centered with respect to the respective edge portion of the antenna element.

[0016] The antenna element can be square-shaped, rectangular-shaped, circular-shaped or elliptical-shaped.

[0017] A ground element can be provided on a second surface of said second substrate.

[0018] To improve gain and for beam forming a third substrate can be provided. On a first surface of the third substrate additional antenna elements are arranged. The third substrate is arranged on the first substrate, in other words such that the main antenna element is interposed between the first surface of the first substrate and a second surface of the third substrate.

[0019] Preferably, the additional antenna elements are arranged symmetrically with respect to the center of the main antenna element.

[0020] To achieve electromagnetical coupling, the additional antenna elements are arranged to overlap with the main antenna element.

[0021] The additional antenna elements may be square-shaped, rectangular-shaped, circular-shaped or elliptical-shaped.

[0022] To solve the above second object a microstrip antenna device is provided comprising a first substrate; a square-shaped antenna element provided on a first surface of the first substrate; a second substrate; a first elongated feeding element provided between a second surface of the first substrate and a first surface of the second substrate; and a second elongated feeding element provided between the second surface of said first substrate and the first surface of the second substrate; wherein the first feeding element and the second feeding element are arranged to overlap with the antenna element such that an end portion of the first feeding element beneath said square-shaped antenna element and an end portion of the second feeding element beneath the square-shaped antenna element are not in contact with each other.

[0023] Advantageously, an end portions of the first and of the second elongated feeding element are positioned within a range of $-0,5(L-W)$ and $+0,5(L-W)$ from an respective edge portion of the square-shaped antenna element. Here, L is the extension of said square-shaped antenna element in a direction parallel

to the direction of overlap and W is the width of the respective elongated feeding element.

[0024] Also in this embodiment, it is essential to realize that according to the invention no overlap between the antenna element and the feeding element is required. In contrast to prior art devices, an overlap-free arrangement is the basis for the design and evaluation of microstrip antennas suitable for different purposes. Therefore, a microstrip antenna essentially free from overlap between the main antenna element and the feeding element or elements is the preferred embodiment.

[0025] Moreover, by employing two feeding elements a microstrip antenna device is achieved for receiving horizontally and vertically polarized waves with the same antenna device.

[0026] Typically, the first and second feeding elements are arranged substantially perpendicularly to each other.

[0027] For matching impedances, an impedance-matching means can be provided which usually takes the form of an impedance-matching network connected to the first and second elongated feeding element, respectively.

[0028] The first and/or second elongated feeding element is arranged at the center of the respective edge portion of the square-shaped antenna element.

[0029] A ground element can be provided on a second surface of the second substrate.

[0030] To improve gain and for beam forming a third substrate can be provided. On a first surface of the third substrate additional antenna elements are provided. The third substrate is arranged on the first substrate, in other words such that the square-shaped antenna element is interposed between said first surface of the first substrate and a second surface of the third substrate.

[0031] Preferably, the additional antenna elements are arranged symmetrically with respect to the center of the square-shaped antenna element.

[0032] The additional antenna elements are arranged to overlap with said main antenna element to achieve an electromagnetical coupling.

[0033] The additional antenna elements may be square-shaped, rectangular-shaped, circular-shaped or elliptical-shaped.

[0034] To solve the above third object the present invention provides a reception apparatus for receiving broadcast signals comprising a microstrip antenna device as described above for receiving a broadcast signal and a converter means for converting the frequency of the received first broadcast signal. Advantageously, said converter means is provided in planar waveguide technology to avoid transition losses.

[0035] To solve the above third object the present invention further provides a reception apparatus for receiving broadcast signals comprising a first microstrip antenna device as described above for receiving a first broadcast signal, converter means for converting the

frequency of the received first broadcast signal, a second microstrip antenna device as described above for receiving a second broadcast signal simultaneously to receiving the first broadcast signal and a second converter means for converting the frequency of the received second signal. Advantageously, the first and second converter means are provided in planar waveguide technology to avoid transition losses.

[0036] A switching matrix can be provided for distributing on demand signals received from said converter means.

[0037] To solve the above third object the present invention further provides a reception apparatus for receiving broadcast signals comprising a first microstrip antenna device as described above for receiving a first broadcast signal, a second microstrip antenna device as described above for receiving a second broadcast signal simultaneously to receiving the first broadcast signal, converter means for converting the frequency of the received broadcast signal, and a connecting means being adapted to selectively supply the output signal of one of the first antenna device or the second antenna device to converter means. This embodiment is advantageous as the number of converters is smaller than the number of microstrip antenna devices whereby the reception apparatus of this embodiment is more economical compared to a reception apparatus according to the invention in which the number of converters is equal to the number of microstrip antenna devices.

[0038] Typically, the converter means comprises at least one low-noise amplifier, at least one frequency mixer and at least one local oscillator.

[0039] To minimize losses due to transition, the converter means and/or the connecting means are provided in planar waveguide technology.

[0040] To solve the above third object the present invention further provides a reception apparatus for receiving broadcast signals comprising a first microstrip antenna device as described above for receiving a first broadcast signal and supplying at least one output signal to a first low-noise amplifying means, a second microstrip antenna device as described above for receiving a second broadcast signal simultaneously to receiving the first broadcast signal and supplying at least one output signal to a second low-noise amplifying means, a connecting means being supplied with an output signal from each of said first and second low-noise amplifying means and at least one frequency mixing means being supplied with an output signal from said connecting means.

[0041] To avoid transition losses, at least said first and second amplifying means are provided in planar waveguide technology. However, in order to reduce the complexity of the overall apparatus, also the connecting means and/or the frequency mixing means can be provided in planar waveguide technology.

[0042] Any reception apparatus described above is suitable for receiving broadcast signals from satellites at

two orbital positions. If broadcast signals from more than two orbital positions shall be received additional microstrip antenna device according to the invention can be added to a reception apparatus according to the invention.

[0043] In the following a preferred embodiment and further embodiments of the invention will be described with reference to the drawings.

Fig. 1 and 2 show a top-view and a side-view of a first embodiment of the invention;

Fig. 3 and 4 show a top-view and a side-view of a second embodiment of the invention;

Fig. 5 and 6 show a top-view and a side-view of a third embodiment of the invention;

Fig. 7 shows a DTH satellite reception antenna arrangement;

Fig. 8 shows a first embodiment of the reception apparatus according to the invention;

Fig. 9 shows an arrangement of two microstrip antennas according to the invention for reception of two orbital positions; and

Fig. 10 shows a second embodiment of the reception apparatus according to the invention;

Fig. 11 shows a third embodiment of the reception apparatus according to the invention; and

Fig. 12 shows a fourth embodiment of the reception apparatus according to the invention.

[0044] In a preferred embodiment of an electromagnetically coupled microstrip antenna according to the invention as shown in Fig. 1 and 2, a first substrate 1 has a height h_1 and consists of a dielectric material having a relative permittivity E_1 . An antenna element 2 is provided on a first surface 1a of the first substrate 1. In this embodiment, the antenna element 2 takes the form of a rectangular microstrip patch element having an length of L . A second substrate 3 is provided below the first substrate 1. The second substrate 3 has a height h_2 and consists of a dielectric material having a relative permittivity E_2 . A feeding element 4 is interposed between the first and second substrate. The feeding element 4 may be provided on the second surface 1b of the first substrate 1 or a first surface 3a of the second substrate 3. In this embodiment, the feeding element 4

takes the form of an elongated feeding line.

[0045] In this preferred embodiment of the invention, an end portion 4a of the elongated feeding line 4 is located underneath an edge portion 2a of the microstrip patch element 2 substantially without any overlap ($O = 0\%$). Preferably, the feeding line 4 is centered with respect to the edge portion 2a. In accordance with the invention and as indicated in Fig. 2, the end portion 4a of the elongated feeding line 4 may be located within a range of $-0,3L$ and $+0,3L$ from the edge portion of the microstrip patch element 2 ($O = \pm 30\%$), wherein L is the extension of the antenna element 2 in a direction parallel to the direction of overlap with the feeding element 4. In other words, according to the invention an end portion of the feeding element is positioned within an area symmetrically arranged with respect to an respective edge portion of the antenna element. In the preferred embodiment, the antenna element and the feeding element do not overlap.

[0046] As shown in Fig. 2 a ground element 5 is provided on a second surface 3b of the second substrate 3, the ground element 5 taking the form of a ground plane substantially covering the entirety of the second surface 3b of the second substrate 3.

[0047] Two examples of the preferred embodiment of the invention have been examined. In both examples the relative permittivity of the substrates 1 and 3 was chosen to

$$E1 = E2 = 3.38 \pm 0.05.$$

[0048] In one example the heights of the substrates 1 and 3 were chosen to

$$h1 = h2 = 0,81 \text{ mm.}$$

[0049] In the other example the heights of the substrate 1 and 3 were chosen to

$$h1 = 1,52 \text{ mm and } h2 = 0,81 \text{ mm.}$$

[0050] The two examples were designed by means of a simulation tool based on the method of moments. The design of the microstrip antenna included on the one hand the optimization of the patch length L , the feeding line width W and the overlap O , and on the other hand the impedance-matching network. The patch length L corresponds to the specified resonant frequency (center frequency of the considered frequency range). The feeding line width W was optimized and the best bandwidth was achieved using a 50 Ohm feeding line. The feeding line did not overlap with the antenna element (overlap $O = 0\%$) whereby a broadband matching was realized. The optimized values for the second example ($h1 = 1,52 \text{ mm}$ and $h2 = 0,81 \text{ mm}$) are $L = 5,2 \text{ mm}$, $W = 1,9 \text{ mm}$ and $O = 0 \text{ mm}$.

[0051] With both examples a bandwidth of more than 17.5 % (VSWR ≤ 2) was achieved.

[0052] In a further preferred embodiment of the electromagnetically coupled microstrip antenna according to the invention, which is capable of receiving two perpendicular polarized broadcast signals, as shown in Fig. 3 and 4, a first substrate 11 has a height $h11$ and consists of a dielectric material having a relative permittivity $E11$. An antenna element 12 is provided on a first surface 11a of the first substrate 11. In this embodiment, the antenna element 12 takes the form of a square microstrip patch element having an edge length L . A second substrate 13 is provided below the first substrate 11. The second substrate 13 has a height $h12$ and consists of a dielectric material having a relative permittivity $E12$. A first feeding element 14 is interposed between the first and second substrate. The first feeding element 14 may be provided on the second surface 11b of the first substrate 11 or a first surface 13a of the second substrate 13. In this embodiment, the first feeding element 14 takes the form of an elongated feeding line. A second feeding element 15 is interposed between the first and second substrate. The second feeding element 15 may be provided on the second surface 11b of the first substrate 11 or a first surface 13a of the second substrate 13. In this embodiment, the second feeding element 15 takes the form of an elongated feeding line. The second feeding element 15 extends in a direction substantially perpendicular to said first feeding element 14.

[0053] In this preferred embodiment of the invention, an end portion 14a of the first elongated feeding line 14 is located underneath a first edge portion 12a of the square microstrip patch element 12 substantially without any overlap ($O = 0\%$). Likewise, an end portion 15a of the second elongated feeding line 15 is located underneath a second edge portion 12b of the square microstrip patch element 12 substantially without any overlap ($O = 0\%$). Preferably, the feeding lines 14 and 15 are centered with respect to the respective edge portion 12a and 12b. In accordance with the invention and as indicated in Fig.3, the end portion 14a of the first elongated feeding line 14 and the end portion 15a of the second elongated feeding line 15 may be located such that the first and second elongated feeding line are separated from each other within a range of $-1/2 \cdot (L-W)$ and $+1/2 \cdot (L-W)$ from the respective edge portion of the microstrip patch element 12, wherein L is generally the extension of the antenna element 12 in the direction of overlap with the respective feeding element 14, 15 and W is the width of the feeding element 14, 15. In other words, according to the invention an end portion of the feeding element is positioned within an area symmetrically arranged with respect to an respective edge portion of the antenna element.

[0054] As shown in Fig. 3 a ground element 16 is provided on a second surface 13b of the second substrate 13, the ground element 16 taking the form of ground plane substantially covering the entirety of the second surface 13b of the second substrate 13.

[0055] In Fig. 1 and 3 impedance-matching networks 20 are shown which are provided to match the impedance of the microstrip antenna to, for example, a 50 Ohm system which is usually used in DTH satellite antennas. Each impedance-matching network 20 comprises a first section 21 having a length L1 and a width W1 and a second section 22 having a length L2 and a width W2. The appropriate variation of these values makes it possible to realize impedance matching. The impedance networks 20 are not necessarily identical but may be adapted to the conditions given by the design of the individual feeding element. However, it is advantageous to realize the impedance networks in planar waveguide technology to avoid transition losses.

[0056] To improve beam forming and gain of the electromagnetically coupled microstrip antenna according to the invention, as shown in Fig. 1 to 4, can be provided, as shown in Fig. 5 and 6, with a third substrate 31 on a first surface 31a of which additional antenna elements 32 are provided and which is positioned with a second surface 31b on the first surface 1a, 11a of the first substrate 1, 11. In other words, the main antenna element 2 is interposed between the first and third substrates. The third substrate 31 has a height h31 and consists of a dielectric material having a relative permittivity E31.

[0057] In Fig. 5 and 6 an electromagnetically coupled microstrip antenna having such a third substrate 31 and additional antenna elements 32 is shown which is based on the embodiment of Fig. 1 and 2, however, comprising a square microstrip antenna element 2 provided on the first surface 1a of the first substrate 1. The remaining elements of the embodiment of Fig. 1 and 2 are unchanged and therefore not discussed in further detail. Instead, reference is made to the above description of Fig. 1 and 2.

[0058] As shown in Fig. 5, four additional antenna elements 32a to 32d are provided on the first surface 31a of the third substrate 31. The four additional square antenna elements 32a to 32d are positioned symmetrically with respect to the center of the antenna element 2 on the first surface 1a of the first substrate 1 with a distance d between adjacent edges. The additional square antenna elements 32a to 32d have an edge length of L'. The symmetrical arrangement in both directions secures the same reception conditions for both polarizations. Therefore, the four additional square antenna elements 32a to 32d can be provided advantageously also in the embodiment of Fig. 3 and 4. The additional antenna elements 32 are fed through the overlapping between these elements and the antenna element 2 provided on the first substrate 1. A constructive superposition of the waves and therefore beam forming is possible with this embodiment of the invention.

[0059] With an electromagnetically coupled microstrip antenna according to the invention it is not required to use an adhesive film for attaching the substrates to each other. This kind of attachment achieved by adhesive films is known in the prior art and usually addressed as a multilayer structure. Instead, according to another aspect of the invention the substrates are attached to each other by mechanical attaching means like screws, bolts etc. The resulting structure is called stacked structure. The advantage achieved thereby is that losses which are caused by the presently available adhesive films can be avoided.

[0060] With an electromagnetically coupled microstrip antenna it is possible to provide a reception apparatus which is capable of receiving directly broadcast signals. In a DTH reception arrangement as shown in Fig. 7 a reflector 40 is combined with a reception apparatus 41.

[0061] According to the invention, as shown in Fig. 8, a first embodiment of the reception apparatus 41 comprises an electromagnetically coupled microstrip antenna 42 as described and an LNB 43. Advantageously, the embodiment of Fig. 3 and 4 is employed to supply a signal H for horizontally polarized waves and a signal V for vertically polarized waves to the LNB 43. Since the antenna 42 and the LNB 43 are realized in planar waveguide technology transition losses are avoided.

[0062] For reception of two orbital satellite positions a first and a second antenna 42a and 42b can be provided in a reception apparatus 41 as shown in Fig. 9 showing only a top-view of the microstrip antenna device. Reference is made to Fig. 1 to 6 for further details. The first and the second antenna 42a and 42b are spaced from each other such that broadcast signals from a satellite at a first orbital position can be received simultaneously with broadcast signals from a satellite at a second orbital position. Either the first or the second antenna 42a or 42b is positioned in the focus of the reflector 40 (see Fig. 7) or both antennas 42a and 42b are positioned out of but close to the focus of the reflector 40 (see Fig. 7). These approaches are well known from DTH satellites antenna arrangements comprising a reception apparatus having a feedhorn in hollow waveguide technology and are therefore not discussed here in further detail.

[0063] A second embodiment of the reception apparatus according to the invention is shown in Fig. 10. In this reception apparatus 61, the output signals of the electromagnetically coupled microstrip antennas 62a and 62b, which correspond to the antennas 42a and 42b in Fig. 9 and which are shown in Fig. 10 to output a signal H corresponding to a received horizontally polarized broadcast wave and a signal V corresponding to a received vertically polarized broadcast wave, may be supplied to a single LNB 63 comprising low-noise amplifiers 64a and 64b, frequency mixers 65a and 65b and a local oscillator 66 via a connecting means 67 being adapted for supplying selectively the output signals H, V of one of the microstrip antennas 62a, 62b to the low-noise amplifiers 64a, 64b. The connecting means 67 can be realized by means of a switch for connecting the inputs of the low-noise amplifiers 64a, 64b with either

the outputs H, V of the first microstrip antenna 62a or of the second microstrip antenna 62b. A control signal C is supplied to the connecting means 67 accordingly. The output signals RF of the low-noise amplifiers 64a, 64b are supplied to the frequency mixers 65a, 65b which are also supplied with an output signal from the local oscillator 66. The frequency mixers 65a, 65b comprise outputs 68a, 68b each of which supplying an output signal from the reception apparatus to individual user devices.

[0064] A third embodiment of the reception apparatus according to the invention is shown in Fig. 11. In this reception apparatus 71 the output signals of the electromagnetically coupled microstrip antennas 72a and 72b, which also correspond to the antennas 42a and 42b in Fig. 9 and which are shown in Fig. 11 to output a signal H corresponding to a received horizontally polarized broadcast wave and a signal V corresponding to a received vertically polarized broadcast wave, may be supplied to an individual one of low-noise amplifiers 73a, 73b, 73c, 73d. The output signals of the low-noise amplifiers 73a, 73b, 73c, 73d are supplied to a connecting means 74 being adapted for supplying selectively the output signals RF of the low-noise amplifiers 73a, 73b, 73c, 73d to individual frequency mixers 75a, 75b which are also supplied with an output signal of a local oscillator 76. The connecting means 74 can be realized by means of a switch for connecting the inputs of the frequency mixers 75a, 75b with either the outputs of the low-noise amplifiers 73a, 73b connected to the first antenna 72a or the outputs of the low-noise amplifiers 73c, 73d connected to the second antenna 72b. A control signal C is supplied to the connecting means 74 accordingly. The frequency mixers 75a, 75b comprise outputs 77a, 77b each of which supplying an output signal from the reception apparatus to individual user devices.

[0065] In a fourth embodiment a switching matrix is provided in the reception apparatus 51 according to the invention. The switching matrix distributes the signals from one or more microstrip antennas, LNBs or frequency mixers to outputs supplying an output signal from the reception apparatus to individual user devices. In Fig. 12, a reception apparatus 51 is shown comprising two electromagnetically coupled microstrip antennas 52a and 52b each of which supplying a signal H corresponding to a received horizontally polarized broadcast wave and a signal V corresponding to a received vertically polarized broadcast wave to low-noise amplifiers 53a to 53d. RF signals from the low-noise amplifiers 53a to 53d are supplied to frequency mixers 54a to 54d each of which receiving a reference frequency from a local oscillator 55. IF signals from the individual frequency mixers 54a to 54d are fed to a switching matrix 56 distributing on demand the received IF signals to anyone of the four outputs 57a to 57d. The switching matrix 56 may be realized in planar waveguide technology, like the microstrip antennas and the LNB, to reduce the complexity of the overall system

and to further avoid transition losses. The switching matrix may be combined with any one of the first to third embodiment of the reception apparatus according to the invention as described above with reference to Fig. 8 to 11.

Claims

1. Microstrip antenna device comprising

- a first substrate (1, 11);
- an antenna element (2, 12) provided on a first surface (1a, 11a) of said first substrate;
- a second substrate (3, 13); and
- a first feeding element (4, 14) provided between a second surface (1b, 11b) of said first substrate and a first surface (3a, 13a) of said second substrate; characterized in that
- an end portion (4a, 14a) of said first feeding element (4, 14) is positioned within a range of $-0,3L$ and $+0,3L$ from an edge portion (2a, 12a) of said antenna element (2, 12), wherein L is the extension of said antenna element (2, 12) in a direction parallel to the direction of overlap.

2. Microstrip antenna device according to claim 1, wherein a second feeding element (15) is provided between said second surface (1b, 11b) of said first substrate (1, 11) and said first surface (3a, 13a) of said second substrate (3, 13), an end portion (15a) of said second feeding element (15) is positioned within a range of $-0,3L$ and $+0,3L$ from an edge portion (12b) of said antenna element (2, 12), wherein L is the extension of said antenna element (2, 12) in a direction parallel to the direction of overlap.

3. Microstrip antenna device according to anyone of claims 1 and 2, wherein said first and/or second feeding elements (4, 14, 15) are elongated feeding lines.

4. Microstrip antenna device according to claim 3, wherein said first and second feeding elements (4, 14, 15) are arranged substantially perpendicularly to each other.

5. Microstrip antenna device according to anyone of claims 1 to 4, wherein an impedance-matching means (20) is provided.

6. Microstrip antenna device according to claim 5, wherein said impedance-matching means is an impedance-matching network (20, 21, 22) connected to said first and/or second feeding element (4, 14, 15).

7. Microstrip antenna device according to anyone of

claims 1 to 6, wherein said first and/or second feeding element (4, 14, 15) is arranged at the center of said edge portion (2a, 12a, 12b) of said antenna element (2, 12).

8. Microstrip antenna device according to anyone of claims 1 to 7, wherein said antenna element (2, 12) is square-shaped.

9. Microstrip antenna device according to anyone of claims 1 to 7, wherein said antenna element (2, 12) is rectangular-shaped.

10. Microstrip antenna device according to anyone of claims 1 to 7, wherein said antenna element (2, 12) is circular-shaped or elliptical-shaped.

11. Microstrip antenna device according to anyone of claims 1 to 10, wherein a ground element (5, 16) is provided on a second surface (3b, 13b) of said second substrate (3, 13).

12. Microstrip antenna device according to anyone of claims 1 to 11, wherein a third substrate (31) on a first surface (31a) of which additional antenna elements (32a, 32b, 32c, 32d) are provided, said third substrate (31) being provided such that said antenna element (2) is interposed between said first surface (1a, 11a) of said first substrate (1, 11) and a second surface (31b) of said third substrate (31).

13. Microstrip antenna device according to claim 12, wherein said additional antenna elements (32a, 32b, 32c, 32d) are arranged symmetrically with respect to the center of said antenna element (2).

14. Microstrip antenna device according to anyone of claims 12 and 13, wherein said additional antenna elements (32a, 32b, 32c, 32d) are arranged to overlap with said first antenna element (2).

15. Microstrip antenna device according to anyone of claim 12 to 14, wherein said additional antenna elements (32a, 32b, 32c, 32d) are square-shaped.

16. Microstrip antenna device according to anyone of claims 12 to 14, wherein said additional antenna elements (32a, 32b, 32c, 32d) are rectangular-shaped.

17. Microstrip antenna device according to anyone of claims 12 to 14, wherein said additional antenna elements (32a, 32b, 32c, 32d) are circular-shaped or elliptical-shaped.

18. Microstrip antenna device comprising

- a first substrate (11);
- a square-shaped antenna element (12) provided on a first surface (11a) of said first substrate;
- a second substrate (13);
- a first elongated feeding element (14) provided between a second surface (11b) of said first substrate (11) and a first surface (13a) of said second substrate (13); and
- a second elongated feeding element (15) provided between said second surface (11b) of said first substrate (11) and said first surface (13a) of said second substrate (13); characterized in that
- said first feeding element (14) and said second feeding element (15) are arranged to overlap with said antenna element (12) such that an end portion (14a) of said first feeding element (14) beneath said square-shaped antenna element (12) and an end portion (15a) of said second feeding element (15) beneath said square-shaped antenna element (12) are not in contact with each other.

19. Microstrip antenna device according to claim 18, wherein an end portion (14a) of said first elongated feeding element (14) and an end portion (15a) of said second elongated feeding element are positioned within a range of $-0,5(L-W)$ and $+0,5(L-W)$ from an respective edge portion (12a, 12b) of said square-shaped antenna element (12), wherein L is the extension of said square-shaped antenna element (12) in a direction parallel to the direction of overlap and W is the width of the respective elongated feeding element.

20. Microstrip antenna device according to anyone of claims 18 and 19, wherein said first and second feeding elements (4, 14, 15) are arranged substantially perpendicularly to each other.

21. Microstrip antenna device according to anyone of claims 18 to 20, wherein an impedance-matching means (20) is provided.

22. Microstrip antenna device according to claim 21, wherein said impedance-matching means is an impedance-matching network (20, 21, 22) connected to said first and second feeding element (4, 14, 15), respectively.

23. Microstrip antenna device according to anyone of claims 18 to 22, wherein said first and/or second elongated feeding element (14, 15) is arranged at the center of the respective edge portion (12a, 12b) of said square-shaped antenna element (12).

24. Microstrip antenna device according to anyone of

claims 18 to 23, wherein a ground element (16) is provided on a second surface (13b) of said second substrate (13).

25. Microstrip antenna device according to anyone of claims 18 to 24, wherein a third substrate (31) on a first surface (31a) of which additional antenna elements (32a, 32b, 32c, 32d) are provided, said third substrate (31) being provided such that said square-shaped antenna element (12) is interposed between said first surface (1a, 11a) of said first substrate (1, 11) and a second surface (31b) of said third substrate (31). 5
26. Microstrip antenna device according to claim 25, wherein said additional antenna elements (32a, 32b, 32c, 32d) are arranged symmetrically with respect to the center of said square-shaped antenna element (12). 10
27. Microstrip antenna device according to anyone of claims 12 and 13, wherein said additional antenna elements (32a, 32b, 32c, 32d) are arranged to overlap with said first antenna element (2). 15
28. Microstrip antenna device according to anyone of claim 25 to 27, wherein said additional antenna elements (32a, 32b, 32c, 32d) are square-shaped. 20
29. Microstrip antenna device according to anyone of claims 25 to 27, wherein said additional antenna elements (32a, 32b, 32c, 32d) are rectangular-shaped. 25
30. Microstrip antenna device according to anyone of claims 25 to 27, wherein said additional antenna elements (32a, 32b, 32c, 32d) are circular-shaped or elliptical-shaped. 30
31. Microstrip antenna device according to anyone of claims 1 to 30, wherein the antenna device has a stacked structure. 35
32. Reception apparatus for receiving broadcast signals comprising a microstrip antenna device (42) according to anyone of claims 1 to 31 for receiving a broadcast signal and a converter means (43) for converting the frequency of the received broadcast signal. 40
33. Reception apparatus according to claim 32 wherein said converter means (43) is provided in planar waveguide technology. 45
34. Reception apparatus for receiving broadcast signals comprising a first microstrip antenna device (52a) according to anyone of claims 1 to 31 for receiving a first broadcast signal, converter means (53a, 53b, 54a, 54b, 55) for converting the frequency of the received first broadcast signal, a second microstrip antenna device (52b) according to anyone of claims 1 to 31 for receiving a second broadcast signal simultaneously to receiving the first broadcast signal and a second converter means (53c, 53d, 54c, 54d, 55) for converting the frequency of the received second signal. 50
35. Reception apparatus according to claim 34 wherein said first and second converter means (53a, 53b, 53c, 53d, 54a, 54b, 54c, 54d, 55) are provided in planar waveguide technology. 55
36. Reception apparatus for receiving broadcast signals according to anyone of claims 32 to 35 wherein a switching matrix (56) is provided for distributing on demand signals received from said converter means (43; 53a, 53b, 53c, 53d, 54a, 54b, 54c, 54d, 55). 56
37. Reception apparatus for receiving broadcast signals comprising a first microstrip antenna device (62a) according to anyone of claims 1 to 31 for receiving a first broadcast signal, a second microstrip antenna device (62b) according to anyone of claims 1 to 31 for receiving a second broadcast signal simultaneously to receiving the first broadcast signal, converter means (63) for converting the frequency of the received broadcast signal, and a connecting means (67) being adapted to selectively supply the output signal of one of said first antenna device (62a) or said second antenna device (62b) to said converter means (63). 57
38. Reception apparatus according to claim 37, wherein said converter means (63) comprises at least one low-noise amplifier (64a, 64b), at least one frequency mixer (65a, 65b) and at least one local oscillator (66). 58
39. Reception apparatus according to any one of claims 37 and 38 wherein said converter means (63, 64a, 64b, 65a, 65b, 66) are provided in planar waveguide technology. 59
40. Reception apparatus according to any one of claims 37 to 39 wherein said connecting means (66) are provided in planar waveguide technology. 60
41. Reception apparatus for receiving broadcast signals comprising a first microstrip antenna device (72a) according to anyone of claims 1 to 31 for receiving a first broadcast signal and supplying at least one output signal (H, V) to a first low-noise amplifying means (73a, 73b), a second microstrip antenna device (72b) according to anyone of claims 1 to 31 for receiving a second broadcast signal 61

simultaneously to receiving the first broadcast signal and supplying at least one output signal (H, V) to a second low-noise amplifying means (73c, 73d), a connecting means (74) being supplied with an output signal (RF) from each of said first and second low-noise amplifying means (73a, 73b, 73c, 73d) and at least one frequency mixing means (75a, 75b) being supplied with an output signal from said connecting means.

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42. Reception apparatus according to claim 41 wherein said first and second amplifying means (73a, 73b, 73c, 73d) are provided in planar waveguide technology.

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43. Reception apparatus according to any one of claims 41 and 42 wherein said connecting means (74) are provided in planar waveguide technology.

44. Reception apparatus according to any one of claims 41 to 43 wherein said frequency mixing means (75a, 75b) are provided in planar waveguide technology.

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FIG.1

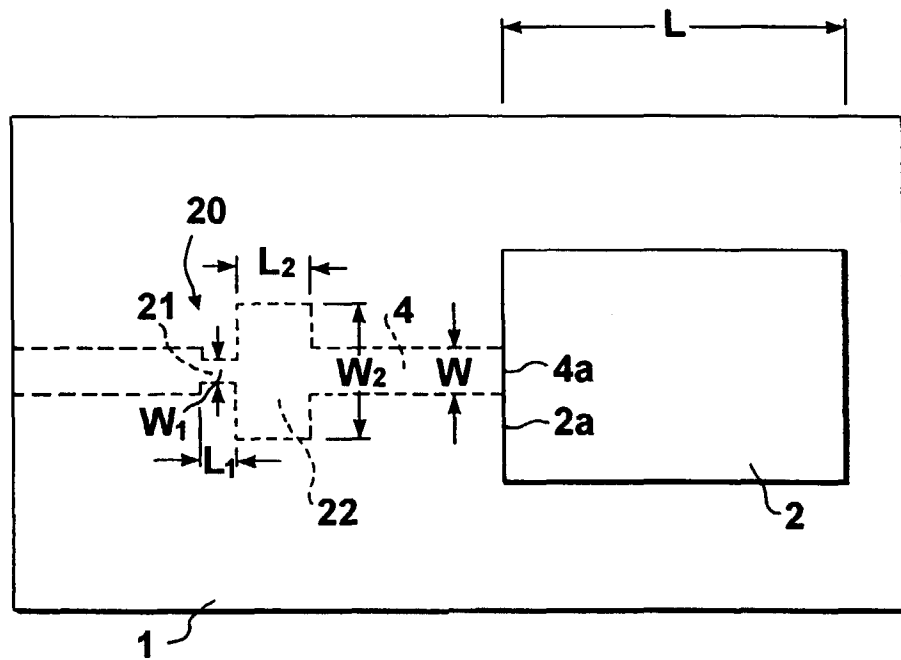


FIG.2

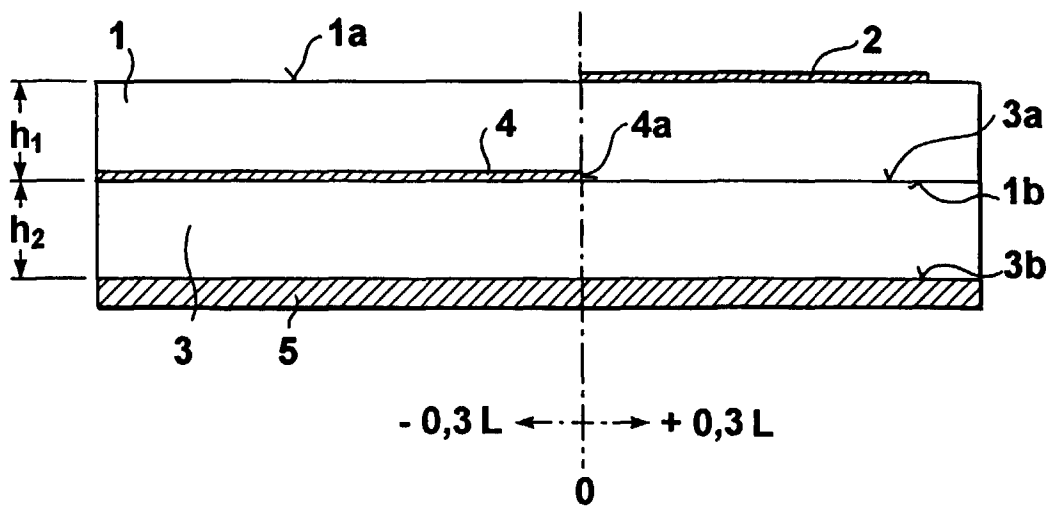


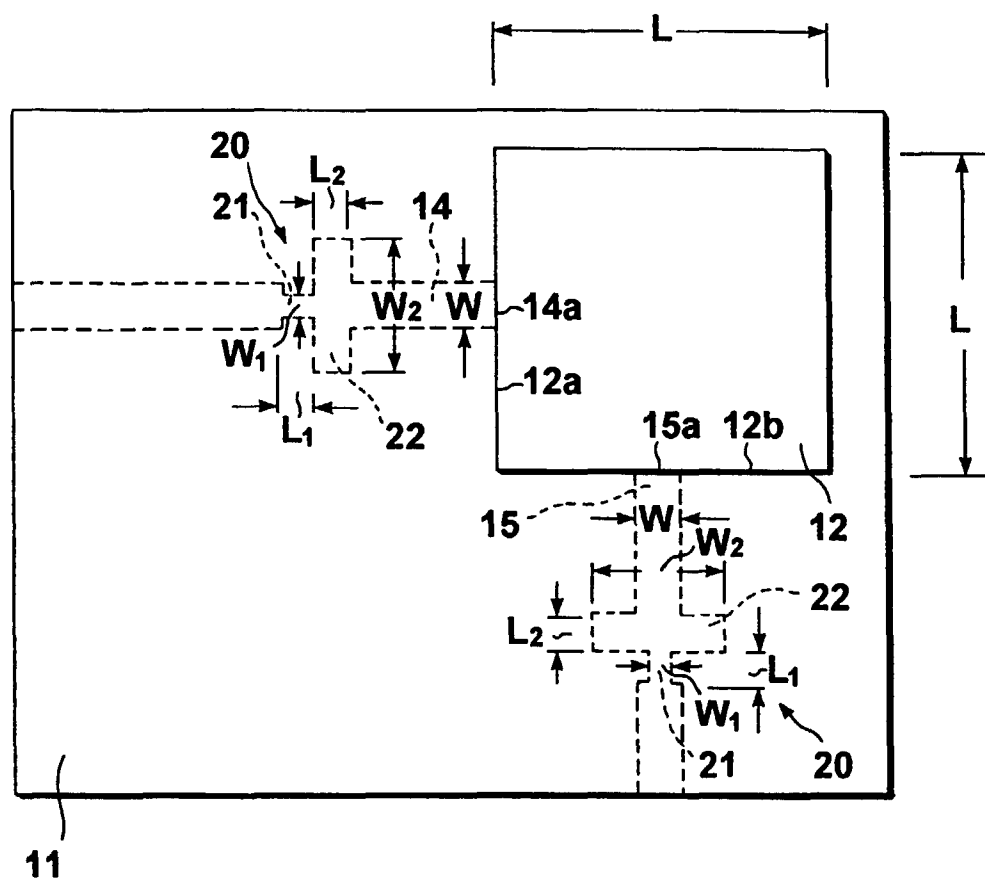
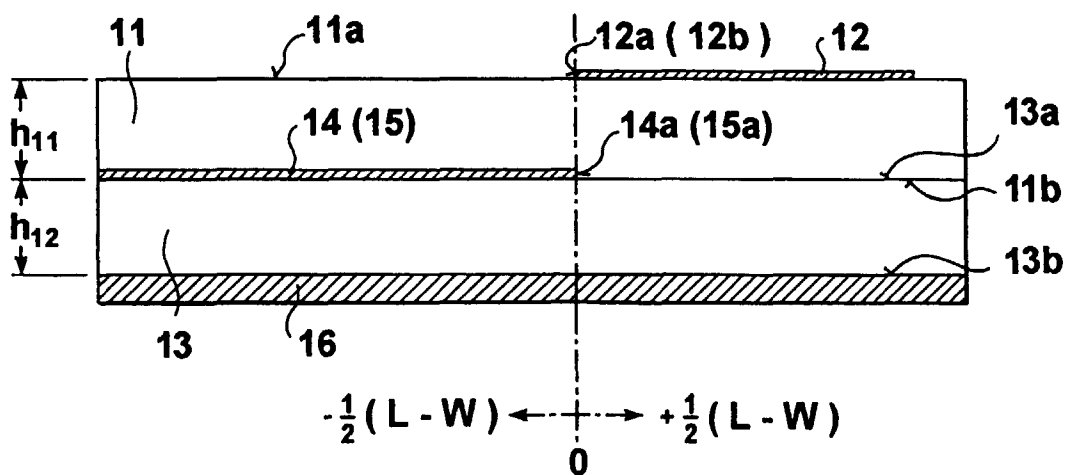
FIG.3**FIG.4**

FIG.5

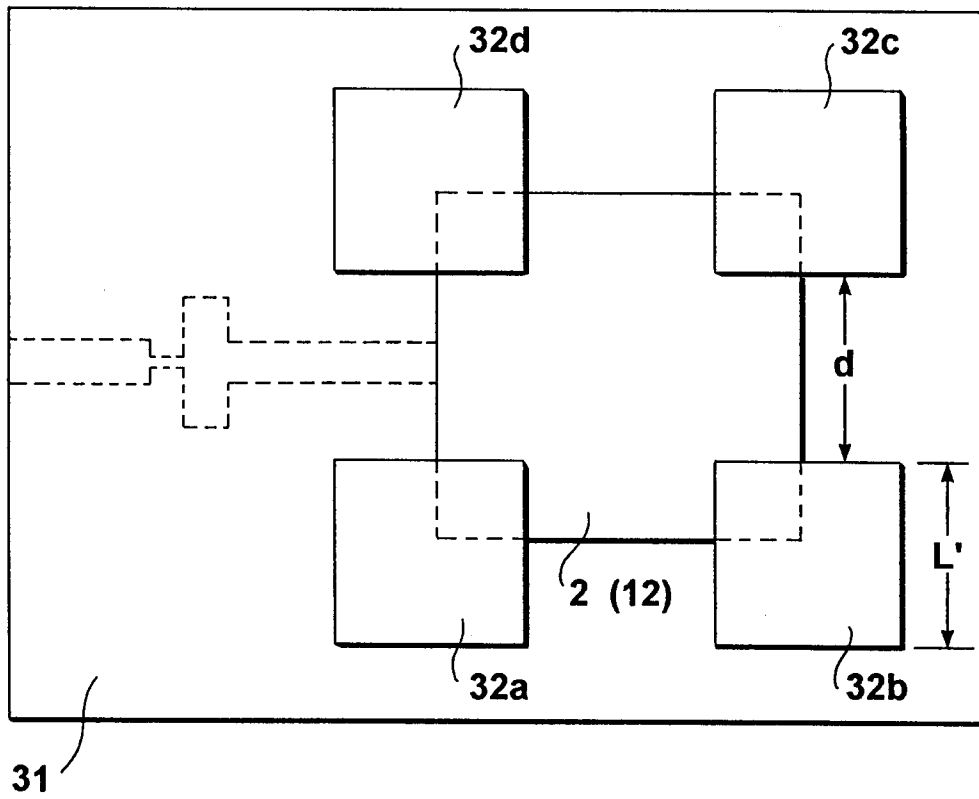


FIG.6

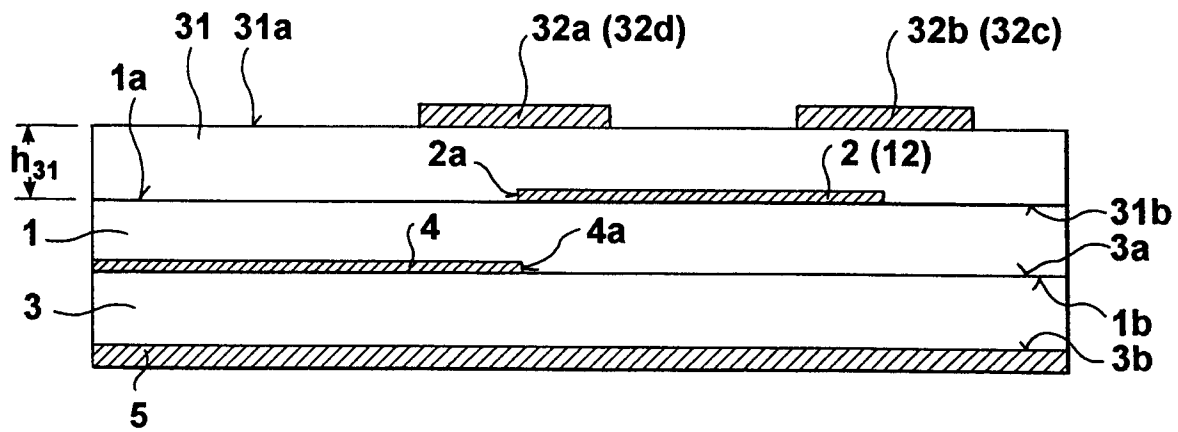


FIG.7

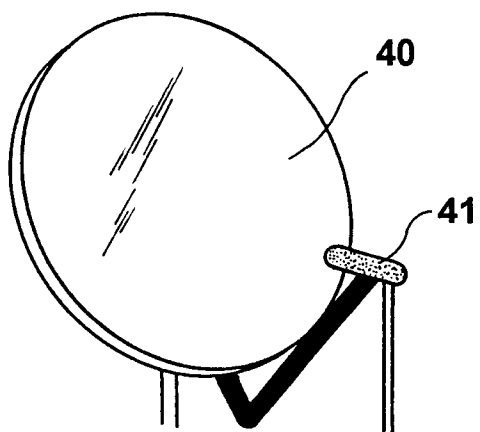


FIG.8

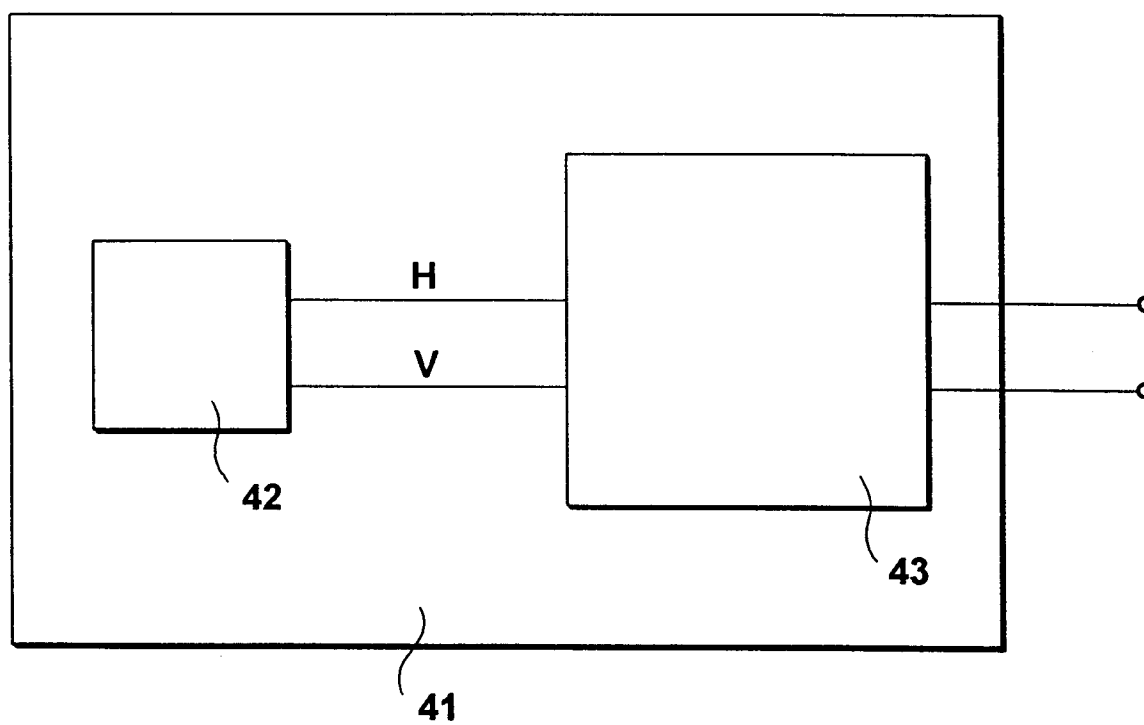


FIG.9

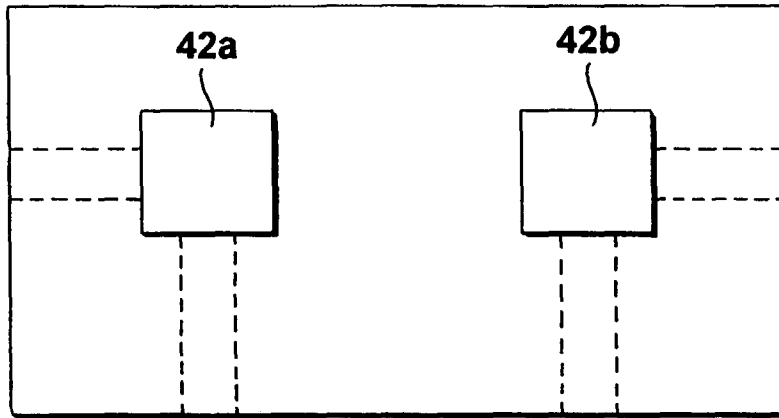


FIG.10

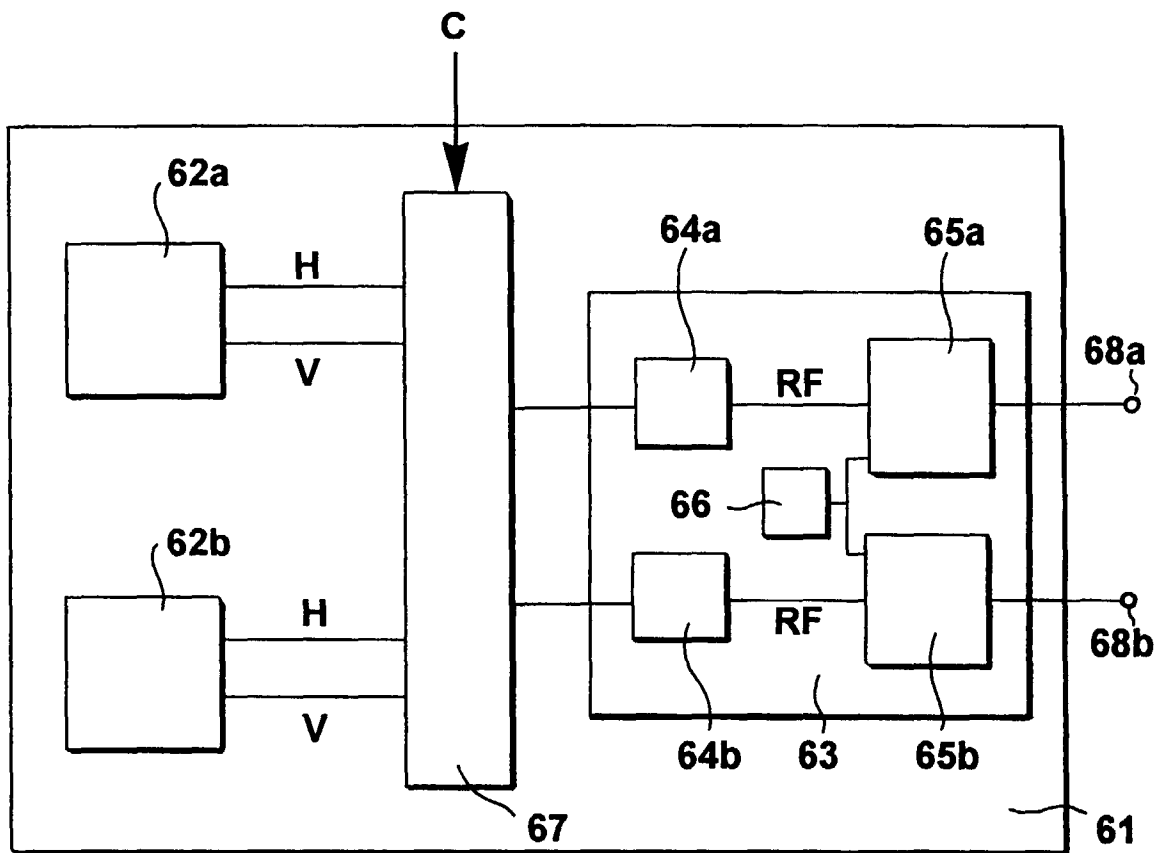


FIG. 11

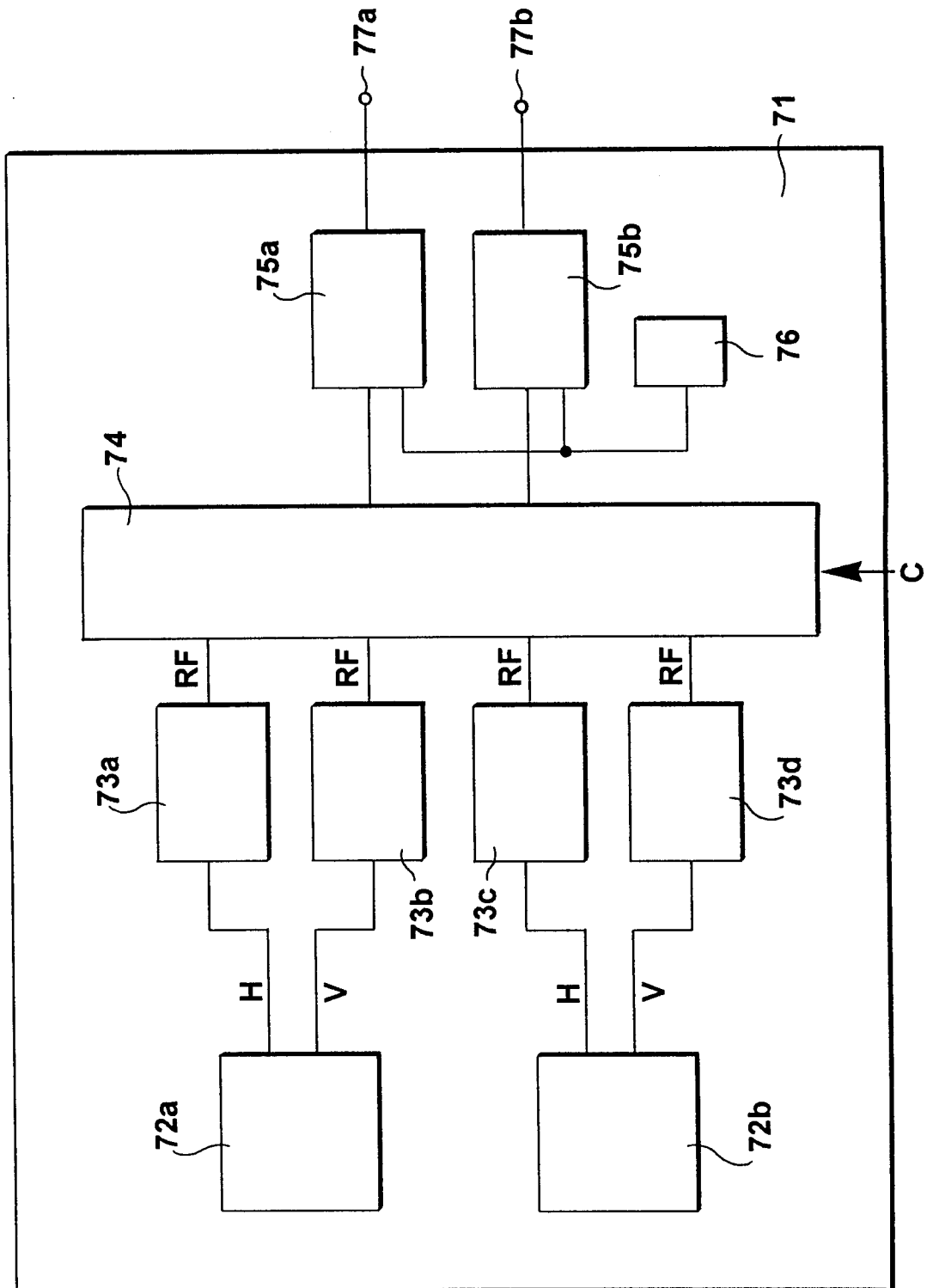
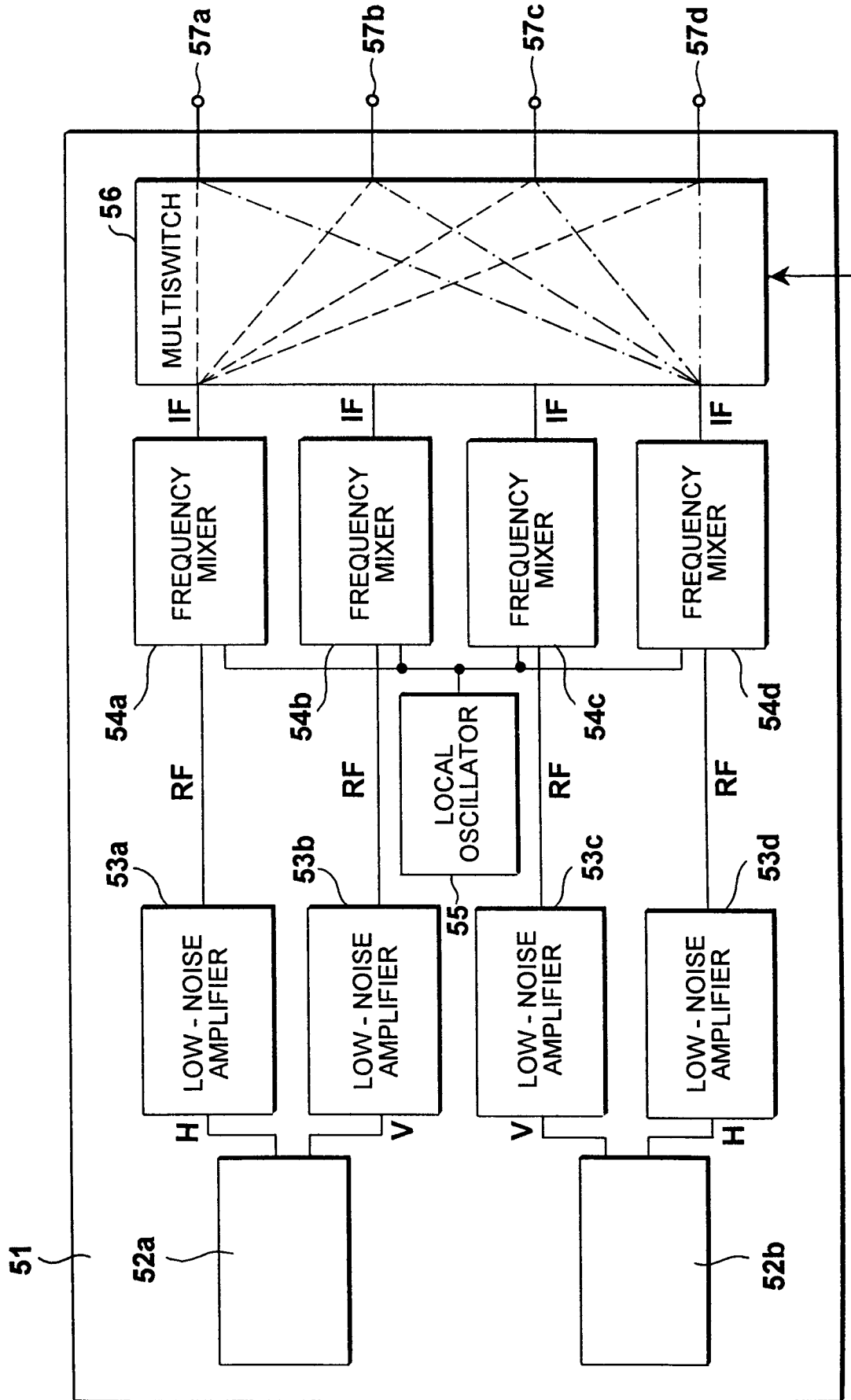


FIG. 12





European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 98 10 8927

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)
X	US 5 471 664 A (KIM) 28 November 1995	1-11, 32-44	H01Q9/04 H01Q1/24 H01Q21/24
Y	* column 2, line 22 - column 6, line 6; figures 1-5 *	12-17	

X	US 5 165 109 A (HAN ET AL.) 17 November 1992	18-31	
Y	* column 3, line 28 - line 58; figures 1,2,7 *	32-44	

X	EP 0 271 458 A (COMMUNICATIONS SATELLITE) 15 June 1988	18-31	
Y	* column 2, line 21 - column 3, line 33; figures 1-10 *	32-44	

Y	EP 0 627 783 A (ALCATEL ET ALCATEL ESPACE) 7 December 1994	12-17	
	* abstract; figures 5-12 *		

Y	EP 0 707 357 A (WANG) 17 April 1996	32-44	
	* column 4, line 15 - column 6, line 25; figures 3-5 *		

A	POZAR ET VODA: "A Rigorous Analysis of a Microstripline Fed Patch Antenna" IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION., vol. ap-35, no. 12, December 1987, pages 1343-1350, XP002080469 NEW YORK US * page 1344 - page 1345; figures 1C-3 *	1-11	

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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 13 October 1998	Examiner Angrabeit, F
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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Application Number
EP 98 10 8927

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	BACON P ET AL: "A DUAL-CHANNEL KU-BAND DBS DOWNCONVERTER" PROCEEDINGS OF THE GALLIUM ARSENIDE INTEGRATED CIRCUITS SYMPOSIUM (GAAS IC), SAN JOSE, OCT. 10 - 13, 1993, no. SYMP. 15, 10 October 1993, pages 233-236, XP000462979 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS -----	32-44	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 13 October 1998	Examiner Angrabeit, F
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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