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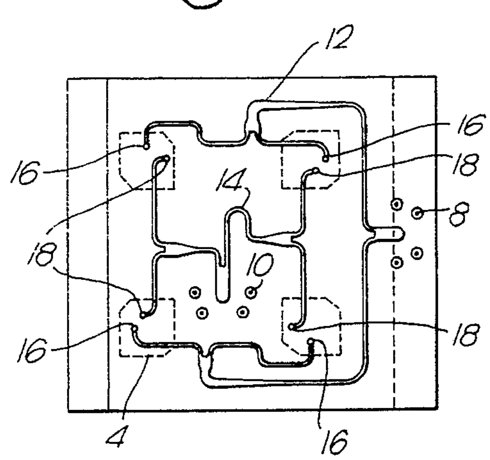
(54) Microstrip antenna.

(57) The invention relates to a microstrip antenna (2) for radiating or receiving circularly polarised radiation. The antenna (2) includes an array of radiation elements (4), a first feed means (12) coupled to the elements (4) in a manner for effecting circular polarisation in a first sense of signals afforded to the elements (4), and further feed means (14) arranged in a non-overlapping relationship with respect to the first feed means (12) and coupled to the elements (4) in a manner for effecting circular polarisation in the opposite sense of signals afforded to the elements (4).

Fig.3.



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MICROSTRIP ANTENNA

This invention relates to microstrip antennae and in particular to microstrip antennae for radiating or receiving circularly polarised radiation.

A known microstrip antenna for radiating or receiving circularly polarised radiation comprises an array of square conducting elements each with two opposite corners bevelled. Each element has two feed points appropriate for left-hand circular polarisation (LHCP) and two feed points appropriate for right-hand circular polarisation (RHCP). Haneishi and Takazawa have proposed, in electronics letters, Vol 21, No 10,9 May 1985, pp 437-8, a 4x4 element RHCP sub-array, formed by four 2x2 element sub-groups on a ground plane; each sub-group is formed of four elements, each arranged such as to be rotated by 90° with respect to its neighbours in the sub-group. The elements in each 2x2 sub-group are connected via H-feeds linked in pairs to the input/output terminal of the 4x4 element sub-array. The H-feed connections are off-centre to give the correct phasing for the respective element orientations. This array has the disadvantage that its use is limited to one sense of circular polarisation determined by the feed points used at the elements.

One form of microstrip antenna array suitable for use with the orthogonal linear polarisations is described in US Patent No 4,464,663. It comprises a linear array of pairs of square microstrip antenna elements, each connected to two feeds so that one feed renders each element responsive to two feeds so that one feed renders each element responsive to one of two orthogonal linear polarisations and the other feed renders each element responsive to the other of the two orthogonal linear polarisations. In this way, the connections between the two input/output ports and the four associated elements render each of these four elements responsive to respective orthogonal linear polarisations. The element pairs are operated back-to-back by a feed and the necessary 180° phase correction is provided by the asymmetrical connection. In this way, the isolation between the two polarisation feeds is enhanced. This antenna array is narrow-band and both orthogonal linear polarisations operate at the same frequency. GB Patent 2,189,080 describes a two-dimensional microstrip antenna array which can be used for both senses of circular polarisation simultaneously and independently, thus allowing simultaneous transmission and reception. The array consists of a number of circularly polarised elements fed by a dual interlaced feed network to provide independent dual right hand and left hand circular polarisation. The antenna is configured from sub-groups consisting of 2x3 elements, each subgroup constituting two 2x2 element sub-arrays with two elements common to both sub-arrays. The sub-arrays are therefore arranged side by side with the feed network providing the polarisation in one sense arranged side by side with the feed network providing polarisation in the opposite sense. The relative orientation or elements in the group and the mutual phasing in the feed networks conforms to the requirements of the broadbanding technique now commonly known in this art as 'sequential rotation'. This term will be assumed to be understood by persons familiar with microstrip antenna techniques and will not therefore, be described further in the context of the present application.

The present invention seeks to provide an improved compact and relatively low profile microstrip antenna array with a simplified feed arrangement and for which a number of arrays can be readily combined to provide a composite array of arbitrary shape.

Accordingly, there is provided a microstrip antenna comprising an array of microstrip antenna radiation elements, first feed means coupled to the elements in a manner for effecting circular polarisation in a first sense of signals afforded to the elements, and further feed means arranged in a non-overlapping relationship with respect to the first feed means and coupled to the elements in a manner for effecting circular polarisation in the opposite sense of signals afforded to the elements.

Preferably the array comprises a 2x2 rectangular array of radiation elements.

Advantageously, the radiation elements are of square shape having two chamfered oppositely disposed corners.

For a 2x2 rectangular array, the radiation elements are mutually disposed at substantially 90° with respect to each other and the first and further feed means to the radiation elements are each, from signal feed points, progressively increased in length by one-quarter the wavelength of the signals.

Preferably, the first and or further feed means are arranged coplanar with the radiation elements. In a preferred embodiment the first and or further feed means are arranged as a triplate layer disposed to underlie the radiation elements. The triplate layer may be laterally displaced with respect to the radiation elements. The radiation elements may be coupled to the first and or further feed means by way of direct, probe, gap or aperture coupling techniques.

The present invention further provides an antenna array comprising a plurality of microstrip antennas having any combination of the features as recited above.

The radiation elements are, preferably, mutually spaced by approximately 85% of the wavelength of the signals.

The present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 shows schematic plan and side views of a microstrip antenna having coplanar radiation elements and feed network;

Figure 2 shows schematic plan and side views of a microstrip antenna having a triplate feed network; and

Figure 3 shows a schematic plan view of a microstrip antenna incorporating a preferred form of feed network.

Referring to the drawings, in which like reference numerals have been used to designate like parts of the invention, a microstrip antenna 2 comprises, in the embodiment shown, four radiation elements 4 arranged as a 2x2 array in the form of a microstrip layer on a substrate 6. The substrate 6 may comprise any suitable dielectric such as RT/duroid material.

The elements 4 are coupled to ports 8,10 by means of a feed network which includes a first or outer feed 12 and a further or inner feed 14. In the embodiment shown the outer feed 12 is arranged so as to provide left hand circular polarisation (LHCP) and the inner feed 14 is arranged so as to provide right hand circular polarisation (RHCP) of signals fed via the ports 8, 10. The ports 8,10 serve, respectively, as LHCP and RHCP ports. The spacing of the elements 4 is, preferably, chosen to be about 85% of the signal wavelength. The advantages of this mutual spacing are that it is large enough to enable the feed networks 8, 10 to be accommodated within the area between the patches, as shown in Figure 3, and it also ensures that the mutual coupling between the patches 4 is relatively weak. Furthermore, the spacing is not sufficiently large to allow grating lobes to appear in the antenna radiation pattern and thereby reduce the directivity of the antenna. Moreover, the axial ratio of the elements 4 may be optimised at the required centre frequency of radiation by suitable choice of the length of the side of the square elements 4 and the degree of chamfering at the comers of the elements.

Each element 4 is capable of simultaneously radiating both LHCP and RHCP radiation from independent orthogonally positioned feed points 16, 18, as shown in Figure 3. A sequentially rotated feed system is also used for the outer and inner feeds 12, 14. To achieve sequential rotation each element 4, for the four element array shown in the drawings, is rotated by 90° with respect to neighbouring patches and the outer and inner feeds 12,14 are arranged to increase in length between consecutive elements by one-quarter the wavelength of the signal to be radiated. One form of feed network providing sequential rotation is shown in Figure 3, where it can be seen that the increase in feed path length between the ports and consecutive elements occurs in an anti-clockwise direction for the outer (LHCR) feed 12 and a clockwise direction for the inner (RHCP) feed 14.

It can be seen from Figures 1 to 3 that, in contrast to known forms of circularly polarised microstrip array antennas, the feeds 12, 14 are arranged in a non-overlapping relationship. This is particularly advantageous as the feeds 12, 14 can, therefore, be arranged coplanar with the elements 4 in a purely microstrip configuration, as shown schematically in Figure 1, with the elements 4 coupled to the feeds 12,14 by either direct coupling or gap coupling techniques, as is known in this art.

Alternatively, the feeds 12, 14 may be incorporated in a separate triplate layer 20, as shown schematically in Figure 2. As is known in this art the triplate layer 20 comprises a feed layer 20a, in which the feeds 12, 14 are defined, arranged between dielectric layers 20b and 20c. The feeds 12, 14 of the feed layer 20a are coupled to the elements 4 using either direct coupling, such as pins or plated through holes extending through the substrate between the triplate feed layer 20a and the elements 4, or aperture coupling through small areas in a shared ground plane 22 which have been cleared of metallisation used to form the ground plane. The use of a triplate layer 20 for the feeds 12, 14 ensures that the circularly polarised radiation from the elements 4 is not adversely affected by spurious radiation from the feeds 12,14. Furthermore, the layout of the feeds 12, 14 can also be optimised so as to be substantially independent of the layout of the elements 4, such as laterally displacing the layout of the feeds relative to the elements. This flexibility of design can be particularly advantageous when a number of antennas are configured into a larger array. The layered structure of the antenna incorporating a triplate feed layer can be seen from Figure 2.

The ports 8,10 may comprise any suitable microwave connector, such as SMA surface mount type connectors, protruding from a ground plane 24 of the array and the elements 4 may be fed by probes coupling, by way of the means as described above, the elements to the triplate layer 20.

It can be seen from the above that the present invention provides an antenna of low profile with considerable design flexibility. Furthermore, the antenna can be used as a common building block of simple construction that can be used to construct larger arrays of arbitrary gain and shape which may also be made substantially conformal to curved surfaces. The antenna lends itself readily to mass construction using conventional manufacturing techniques, providing a consistency of performance required for many practical applications for this type of antenna.

Although the present invention has been described with respect to a particular embodiment modifications may be effected whilst remaining within the scope of the invention. For example, the antenna need not necessarily comprise a 2x2 array of elements. Two elements, or three elements in a triangular disposition can also be used with appropriate modifications of the feed system to meet the requirements of sequential rotation. Furthermore, other shapes of element may be used such as square shape elements having a diagonally cut rectangular slot or circular patches having diametrically opposed lugs or indentations.

Claims

1. A microstrip antenna comprising an array of microstrip antenna radiation elements, first feed means coupled to the elements in a manner for affecting circular polarisation in a first sense of signals afforded to the elements, and further feed means arranged in a non-overlapping relationship with respect to the first feed means and coupled to the elements in a manner for effecting circular polarisation in the opposite sense of signals afforded to the elements.

2. A microstrip antenna as claimed in Claim 1, wherein the array comprises a 2 x 2 rectangular array of radiation elements.

3. A microstrip antenna as claimed in Claim 1 or Claim 2, wherein the radiation elements are mutually disposed at substantially 90° with respect to each other and the first and further feed means to the radiation elements are each, from signal feed points, progressively increased in length by one-quarter the wavelength of the signals.

4. A microstrip antenna as claimed in any one of Claims 1 to 3, wherein the radiation elements are of square shape having two chamfered oppositely disposed corners.

5. A microstrip antenna as claimed in any one of Claims 1 to 4, wherein the first and/or further feed means are arranged coplanar with the radiation elements.

6. A microstrip antenna as claimed in any one of Claims 1 to 4, wherein the first and/or further feed means are arranged as a triplate layer disposed to underlie the radiation elements.

7. A microstrip antenna as claimed in any of the Claims 1 to 4 wherein the first and/or further feed means are arranged as a triplate layer laterally displaced with respect to the radiation elements.

8. A microstrip antenna as claimed in any one of Claims 1 to 7, wherein the radiation elements are coupled to the first and/or further feed means by way of direct or probe or gap or aperture coupling techniques.

9. A microstrip antenna as claimed in any one of Claims 1 to 8, wherein the radiation elements are mutually spaced by approximately 85% of the wavelength of the signals.

10. An antenna array comprising a plurality of microstrip antennae according to any one of Claims 1 to 9.

Fig.1.

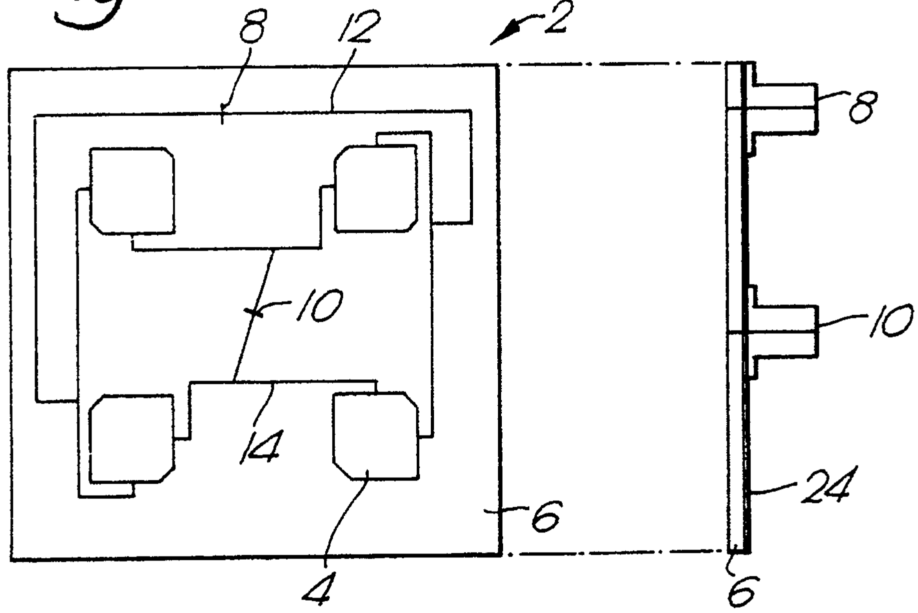

Fig.2.

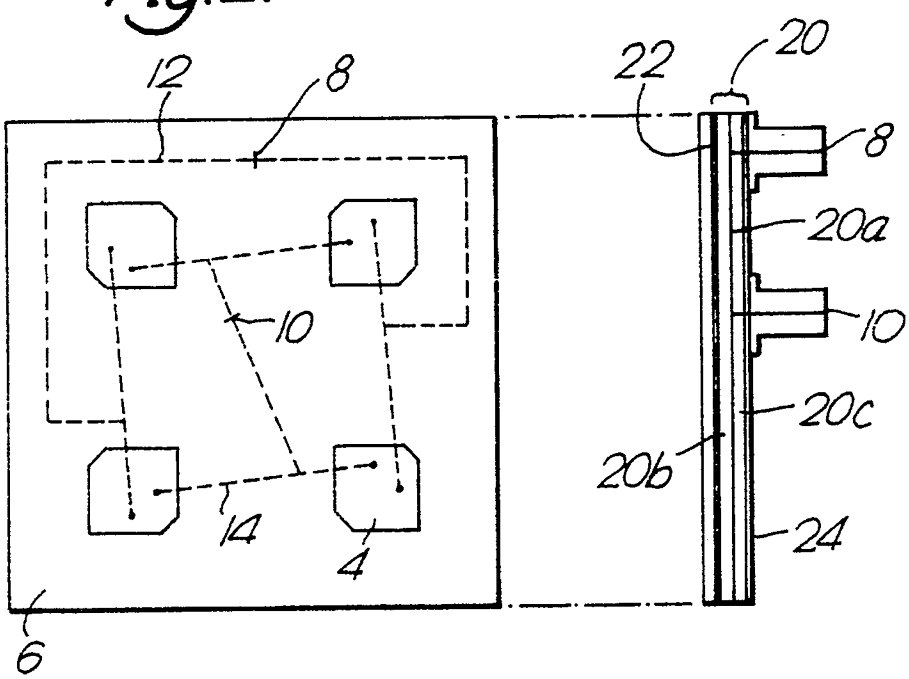

Fig.3.