An electromagnetic power divider/combiner comprises N radial outputs (31) having equal powers and preferably equal phases, and a single axial output (20). A divider structure (1) and a preferably identical combiner structure (2) are broadside coupled across a dielectric substrate (30) containing on one side the network of N radial outputs (31) and on its other side a set of N equispaced stubs (42) which are capacitively coupled through the dielectric substrate (30) to the N radial outputs (31). The divider structure (1) and the combiner structure (2) each comprise a dielectric disk (12, 22, respectively) on which is mounted a set of N radial impedance transformers (14, 24, respectively). Gross axial coupling is determined by the thickness of the dielectric layer (30). Rotating the disks (12, 22) with respect to each other effectuates fine adjustment in the degree of axial coupling.

11 Claims, 3 Drawing Figures
RADIAL/AXIAL POWER DIVIDER/COMBINER

STATEMENT OF GOVERNMENT INTEREST

The invention described herein was partially made in the performance of work under NASA Contract No. JPL-957333 and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958 (72 Stat. 435; 42 U.S.C. 2457).

DESCRIPTION

1. Technical Field

This invention pertains to the field of dividing and combining electromagnetic power.

2. Background Art

U.S. Pat. No. 4,234,854 describes an amplifier which includes a radial structure that divides the input power, piecewise amplifies it, and then recombines it. This device differs from that of the present invention in that: (1) the only output is coaxial, as compared with the radial and coaxial components in the present invention; (2) it amplifies the input power, whereas the present invention does not; and (3) it is much more difficult in the patented device to control the phase and amplitude within the individual pieces.

U.S. Pat. Nos. 4,263,568, 4,328,471, and 4,371,845 disclose radial power dividers which do not have the radial and coaxial components in the present invention;

U.S. Pat. Nos. 4,129,839, 4,254,386, and 4,463,326 disclose planar dividers which do not have the equi-spaced radial components or the axial component of the present invention.

DISCLOSURE OF INVENTION

The electromagnetic power divider/combiner of the present invention features an elongated input conductor (10), such as the inner conductor of a coaxial cable, which conveys the electromagnetic input energy. Generally orthogonal to the input conductor (10) is a substantially planar layer (3) comprising N elongated radially-oriented conductors (31) each of which conveys an equal percentage of the power that originated at the input conductor (10). Each of the radial outputs (31) is directly electrically coupled to the input conductor (10). Generally colinear with the input conductor (10) and separated therefrom by a dielectric portion (30) of the planar layer (3) is an elongated axial output conductor (20).

The input conductor (10) is coupled to the radial outputs (31) by means of N divider impedance transformers (14), each generally a quarter wavelength long at the design frequency, radially grouped on a dielectric disk (12). Similarly, the axial output conductor (20) is capacitively coupled to each of the radial outputs (31) by means of N combiner impedance transformers (24) that are radially arranged on a dielectric combiner disk (22). The divider disk (12) and input conductor (10) are principal ingredients of a divider structure (1). Similarly, the combiner disk (22) and the axial output conductor (20) are principal ingredients of a combiner structure (2). The divider structure (1) and the combiner structure (2) are preferably identical. Each pair of transformers (14, 24) constitutes a power coupler.

The thickness of dielectric layer (30) governs the percentage of power that couples into the axial output (20). Fine tuning of this percentage is effectuated by means of rotation of the combiner structure (2) with respect to the divider structure (1).

BRIEF DESCRIPTION OF THE DRAWINGS

These and other more detailed and specific objects and features of the present invention are more fully disclosed in the following specification, reference being had to the accompanying drawings, in which:

FIG. 1 is an exploded isometric view of a preferred embodiment of the present invention;

FIG. 2 is a nonexploded isometric view of the embodiment of the present invention that is illustrated in FIG. 1; and

FIG. 3 is a plan view of the underside of the dielectric board (30) that is illustrated in FIGS. 1 and 2.

BEST MODE FOR CARRYING OUT THE INVENTION

In the embodiment illustrated herein, N is equal to 6; however, N can be any positive integer subject only to the constraints of physical crowding.

Input conductor (10) is shown as the center conductor of a coaxial cable having an outer conductor (11), which is grounded to the conductive upper (with respect to the arbitrary perspective of the Figures) surface of dielectric disk (12). Layer (13) is typically a thin metalized layer adhering to disk (12). Center conductor (10) passes through disk (12) and is connected on the bottom side thereof to the center point of a radial network of N impedance transformers (14) which are preferably substantially identical and radially equispaced about disk (12).

Each impedance transformer (14) is tapered, having a narrow end connected to conductor (10) at the mid-point of the bottom surface of disk (12), and a wide end positioned radially outwardly from said mid-point. The widths of the impedance transformers (14) are a function of the desired impedance. The length of each impedance transformer (14) is a function of the electromagnetic frequency and the desired impedance transformation ratio. For example, if the input impedance seen by conductor (10) is 50 ohms and it is desired to maintain this 50 ohm impedance at each of the radial outputs (31), then each impedance transformer (14) must be 6 to 1 transformer, since this will transform the impedance from 50 ohms to 300 ohms at the mid-point of disk (12) (six 300 ohm impedances in parallel are equivalent to a single 50 ohm impedance).

Tuning stubs (15), typically lumps of indium or gold, are placed on transformers (14) as desired to achieve fine tuning. Transformers (14) are preferably thin, conductive layers of, e.g., copper. Since it is desired to maintain balance in the power and preferably in the phase at the radial outputs (31), the dimensions of transformers (14) in the area of the mid-point of disk (12) are critical. Techniques of photolithography can be gainfully employed to maintain the desired accuracy. For example, a drawing of the desired geometry, orders of magnitude larger than the dimensions of the final divider/combiner, is accurately made. Photographic techniques are used to reduce this drawing to the desired dimensions of the mask that etches the copper on the dielectric board (12). This results in greater accuracy than if the initial drawing were made to scale. Similar techniques, which offer the additional advantage of facilitating mass production, are used for combiner structure (2).

Radial outputs (31) are thin conductive layers of, e.g., etched copper mounted on the upper surface of dielec-
A passive electromagnetic power divider/combiner for simultaneously outputting power both axially and radially, said divider/combiner comprising:

an elongated input conductor for conveying electromagnetic input energy;

generally orthogonal to the input conductor, a substantially planar dielectric layer overlaid with several elongated generally radial output conductors, each of which is coupled to the input conductor and each of which conveys a equal percentage of the power in the input conductor, wherein the total power outputted by the radial output conductors is less than the power in the input conductor, and generally colinear with the input conductor and electrically separated therefrom by the dielectric layer, an elongated axial output conductor capacitively coupled to the input conductor via several radially arranged, substantially identical combiner impedance transformers, each of which is capacitively coupled to one of the radial output conductors across dielectric layer, and each of which is connected to the axial output conductor, wherein the input conductor power that is not outputted by the radial output conductors is outputted by the axial output conductor.

2. The divider/combiner of claim 1 wherein the radial output conductors are respectively coupled to the input conductor by a set of substantially identical divider impedance transformers each a quarter wavelength long at the design frequency.

3. The divider/combiner of claim 2 wherein each divider impedance transformer is an elongated tapered conductor having a wide end connected to an end of a corresponding radial output conductor, and a narrow end connected to an end of the input conductor.

4. The divider/combiner of claim 2 wherein the divider impedance transformers are equispaced radically.
on a substantially flat divider dielectric disk that is generally orthogonal to the input conductor.

5. The divider/combiner of claim 2 wherein the divider impedance transformers are fabricated by a process of photolithography.

6. The divider/combiner of claim 1 further comprising a set of substantially identical isolation resistors, each isolation resistor separating an adjacent pair of radial output conductors, said resistors insuring that the phase of the electromagnetic energy within each radial output conductor is substantially identical at identical distances thereof.

7. The divider/combiner of claim 1 wherein the dielectric layer has an input side to which the radial output conductors are attached, said dielectric layer separating the input conductor from the axial output conductor; wherein the percentage of power that couples from the input conductor to the axial output conductor is regulated by the thickness of the dielectric layer, the thinner the dielectric layer the greater said axial coupling.

8. The divider/combiner of claim 1 in which the combiner impedance transformers are fabricated by a process of photolithography.

9. The divider/combiner of claim 1 wherein:

10. The divider/combiner of claim 1 wherein the number N of radial output conductors is preselected;

11. A method for effectuating fine adjustments in the percentage of power that is coupled from the input conductor to the axial output conductor of the divider/combiner of claim 10, said method comprising the step of:

   rotating the combiner dielectric disk in its plane.