

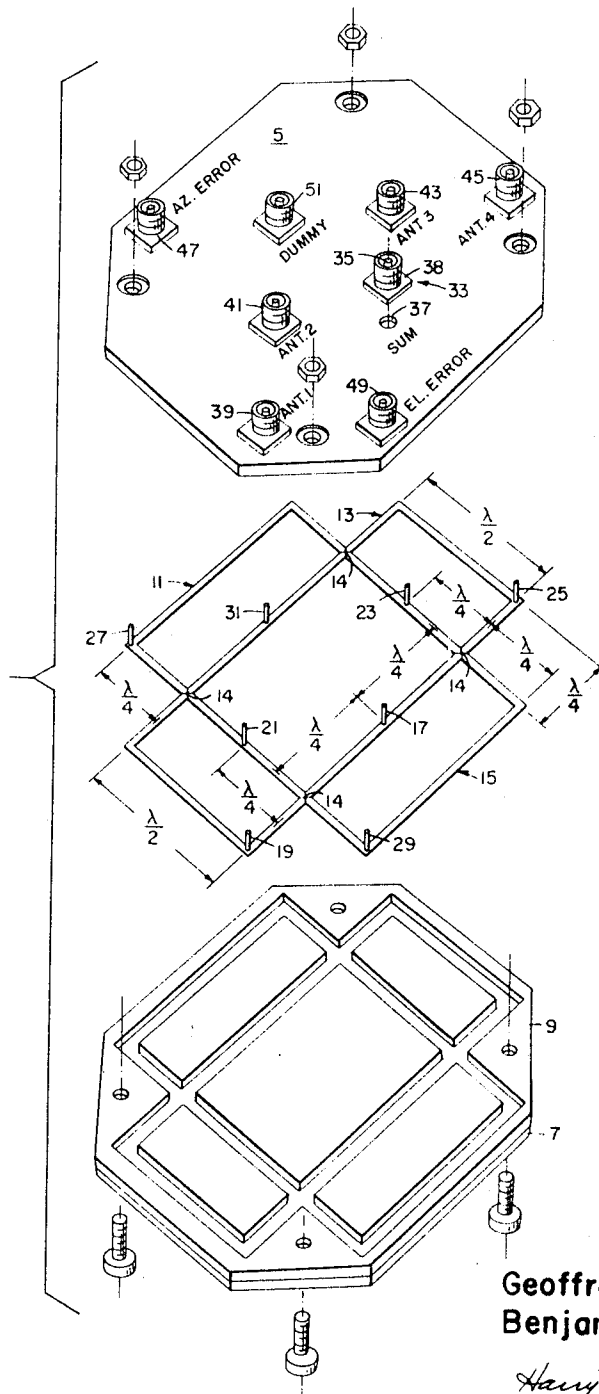
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INTEGRAL MULTIPLE HYBRID COMPARATOR

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INTEGRAL MULTIPLE HYBRID COMPARATOR
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ABSTRACT OF THE DISCLOSURE

An integral multiple hybrid comparator that combines the function of four separate hybrid rings and their interconnecting cables. The comparator will take a signal from a transmitter and divide it equally between four output ports with negligible loss over appreciable bandwidth. Conversely, it will take signals coming in from the four output ports and provide sum and difference outputs. The comparator includes a stripline wherein a conductor array is insulated from and sandwiched between two ground planes. The conductor array includes two overlapping rectangular arrays, each one being one wave length long and one-half wave length side. The conductor array includes a plurality of electrical connection ports arranged so that each port is a multiple of a half wave length from adjacent ports.

This invention relates to a monopulse radar comparator hybrid and more specifically to an integral multiple hybrid comparator of a strip-line configuration which combines the function of four separate hybrid rings and their interconnecting cables.

In the art, resonant hybrid rings (or rat-races) are used in circular form. Their port configuration is conventionally based upon a six quarter-wave length circumference ring with series (or shunt) junctions located predeterminedly about the ring whereby the rings may be interconnected with wave guides, coaxial cables, etc. to form a multiport comparator which is typically used to feed a plurality of antennas or multifeed horn antennas in a monopulse-comparison-radar.

A typical example of the use of the comparator is in a two-co-ordinate (azimuth and elevation) comparison-monopulse tracking radar which has a cluster of four feeds which generate four overlapping antenna beams fed from a single transmitter. All four feeds generate a sum pattern. The difference pattern in one plane is formed by taking the sum of two adjacent feeds and subtracting this from the sum of the other two adjacent feeds. The difference pattern in the orthogonal plane is obtained by adding the difference of the orthogonal adjacent pairs. A total of four hybrid rings are used to generate the sum channel, the azimuth difference channel, and the elevation difference channel.

In a comparator of this nature, four or more of these rings could not be simply connected together in even or odd numbers without the use of special elbows or flexible wave guide to permit an orthogonal matrix form of an array. Present monopulse systems require that their sum and difference signals be in phase within a tolerance of perhaps two or three degrees. This would not be practical if the four additional lines required by conventional circular rings were incorporated into the circuit. Coaxial connectors and flexible coax show phase shift due to any movement, bending, installation, and removal. Such phase shift errors would be unpredictable and intolerable.

It is, therefore, an object of this invention to provide a device which has rectangular resonant rings to form a novel hybrid.

It is further an object of this invention to provide a rectangular configured hybrid which has the same resonant characteristics of the resonant ring ("rat-race").

It is another object of this invention to provide an integral multiple hybrid comparator which eliminates the necessity of interconnecting cables or wave guides.

It is still further an object of this invention to provide a comparator hybrid which is cheaper to manufacture and maintain.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawing.

The single figure is an exploded perspective view of an integral multiple hybrid comparator according to the present invention.

Referring now to the drawing, an integral multiple hybrid comparator of a strip-line structure is shown for use in a two-co-ordinate monopulse tracking radar system. The comparator comprises a pair of parallel metallic ground plates 5 and 7 forming parallel ground planes. Sandwiched between plates 5 and 7 is an insulating member 9 into which a conductor array 11 is imbedded for positioning the conductor array 11 intermediate plates 5 and 7 and insulated therefrom.

The entire assembly is held together by screws in a conventional manner electrically connecting plate 5 to plate 7. The conductor array 11 includes a first rectangular shaped array 13 disposed transversely to a second rectangular shaped conductor array 15 and conductively secured at points of intersection 14 to thus form rectangular resonant rings. Both arrays are one wave length long and one half wave length wide. Further, conductor array 11 is provided with a plurality of electrical connection ports, and for the particular example shown in the drawing, the ports are arranged as follows: port 17 is a summing port disposed intermediate the ends of a first side of rectangular conductor 13, input-output port 19 is disposed in line with port 17 one half wave length from port 17, input-output port 21 is disposed intermediate the ends of a first side of conductor array 15 and one half wave length from port 17, input-output port 23 is disposed intermediate the ends of a second side of array 15 and one half wave length from port 17, input-output port 25 is disposed in line with port 17 on the opposite side as to that of port 19 and one half wave length from port 17, difference port 27 is disposed in line with port 21 and one half wave length from port 21, difference port 29 is disposed in line with port 21 on the opposite side as to that of port 27 and one half wave length from port 21 and difference port 31 is disposed intermediate the ends of a second side of array 13.

Each of the port points is electrically connected to the inner conductor of a coaxial connector, for example, coaxial connector 33 is shown exploded for summing port 17. Connector 33 is disposed over port 17 and the inner conductor 35 extends through aperture 37 in plate 5 for connection to port 17. The outer conductor 38 of connector 33 is conductively secured to plate 5. The remaining connectors are connected to corresponding port points in the same manner.

Connectors 39, 41, 43, and 45 are connected respectively to ports 19, 21, 23, and 25 which are input-output ports and, for the present example, are connected to four separate antennas for both transmitting and receiving. Connectors 47, 49, and 51 are connected respectively to ports 27, 29, and 31 and provide difference signals indicative of the difference in phase of signals received by the antennas. For the particular application, azimuth

error signals are generated at port 27, elevation error signals are generated at port 29, and a dummy load is connected to port 31.

The nature in which these signals are obtained will be discussed later in the description of the operation of the device.

IN OPERATION

The device performs certain basic functions because of the nature of the line lengths of conductor 11 between ports. Inputs sum at certain points, differ at others and split uniformly at still others.

The particular example given here is connected in a monopulse radar system with the transmitter connected to the summing port (connector 33), connectors 39, 41, 43, and 45 are connected to antenna elements, and connectors 47 and 49 are connected to separate receivers of the system.

Transmitter signals are applied to the comparator through connector 33 to summing port point 17 and evenly divided between input-output ports 19, 21, 23, and 25. Note that these four separate antenna feed points are 180 degrees electrically from the driving input point 17 and that difference port points 27, 29, and 31 receive antenna signals that are as follows:

Point 29 receives (ANT 1+ANT 2)—(ANT 3+ANT 4)

Point 27 receives (ANT 2+ANT 4)—(ANT 1+ANT 3)

Point 31 receives (ANT 2+ANT 3)—(ANT 1+ANT 4)

Point 17 receives (ANT 1+ANT 2)+(ANT 3+ANT 4)

Thus, it can be seen that the comparator basically performs, in its application as a monopulse hybrid comparator, a four-way power split in one direction (feeding in the sum port connector 33) and a sum and difference function in the other direction (feeding in the 4 antenna port connectors 39, 41, 43, and 45).

The above description indicates how this new integral multiple hybrid comparator serves as a sum and difference combiner in the precise order required by a monopulse tracking radar system. Further, the device is not limited to feeding dipoles, or 4-horn configurations. It can be employed in the receiving end of a 5-horn feed, as a basic comparator in an antenna array of four interleaving arrays, or adaptable to any previous system using circular hybrid rings of ("rat-races") interconnected with special elbows or flexible wave guide to permit an orthogonal matrix.

Thus, it is obvious that the present device has several advantages over the separately connected hybrid rings. Because interconnecting lines are eliminated, it has wider bandwidth and better balance between ports. Further, weight and cost is reduced by the elimination of a considerable amount of hardware (connectors), interconnecting cables, etc. It is a very compact configuration, approximately one wave length long, when made of rigid air transmission line. It can be constructed using any type of transmission line such as strip-line, wave guide, etc. and is not limited to the coaxial line structure which is discussed as an example. Printed circuit, and strip line version of this integral multiple hybrid comparator may deviate obviously from the straight lines of the rectangular rat-race elements. In the latter cases, curving the rat-race is only an easy and obvious variation, as long as the hybrid rings are interconnectable at common nodal intersections.

While the invention has been described with reference to a preferred embodiment thereof, it will be apparent that various modifications and other embodiments thereof will occur to those skilled in the art within the scope of the invention. Accordingly, it is desired that the scope of this invention be limited only by the appended claims.

What is claimed is:

1. An integral multiple hybrid comparator comprising: a first transmission line array having a predetermined electrical configuration, the total length of said array being

a multiple of one-half wavelengths; a second transmission line array having a like electrical configuration; said first and second array forming at least two closed transmission line loops intersecting at least at four points; said second array being disposed to intersect and cross said first array at right angles thereto and conductively secured thereto at all points of intersection of said arrays; said arrays having a plurality of electrical ports disposed therealong for external transmission line connections, said electrical ports being arranged so that each port is a multiple of a half wave length from adjacent ports; and said ports providing four equally balanced outputs from a single input signal.

2. An integral multiple hybrid comparator as set forth in claim 1, wherein said first and second transmission line arrays are rectangular in form one wave length long and one half wave length wide, said points of intersection of said arrays being one quarter wave length from the ends of each array thereof, thereby forming a plurality of rectangular resonant rings, and wherein at least a sum and three difference outputs are achieved from signals received at four input ports.

3. An integral multiple hybrid comparator as set forth in claim 1, wherein said transmission line arrays are of a strip-line structure including; a pair of parallel ground plates that are electrically connected to each other, and a conductor member disposed between said parallel ground plates, an insulating layer disposed between said ground plates and around said conductor insulating said conductor from said ground plates, a plurality of apertures in one of said ground plates adjacent said electrical ports, a plurality of coaxial connectors having inner and outer conductors, said outer conductor of each of said connectors being conductively secured to said ground plate over one of said plurality of apertures, said inner conductor of each of said connectors being conductively connected to one of said plurality of ports, whereby said comparator may be connected into a microwave transmission system.

4. An integral multiple hybrid comparator as set forth in claim 2, wherein said plurality of electrical ports include a summing port disposed intermediate the ends of a first side of said first rectangular transmission line array, a first input-output port disposed one half wave length from and in line with said summing port, a second input-output port disposed intermediate the ends of a first side of said second rectangular transmission line array, a third input-output port disposed intermediate the ends of a second side of said second rectangular transmission line array, a fourth input-output port disposed in line with and one half wave length from said summing port in an opposite direction as to that of said first input-output port, a first difference output port disposed in line with said second input-output port and one half wave length from said second input-output port, a second difference output port disposed in line with and one half wave length from said second input-output port and in an opposite direction as to that of said first difference port, and a third difference port disposed intermediate the ends of a second side of said first rectangular transmission line array, whereby a signal supplied to said summing port is equally distributed to each of said input-output ports and difference signals are generated at said difference output ports indicative of the difference signals applied to said input-output ports.

References Cited

UNITED STATES PATENTS

3,140,456	7/1964	Lassen et al.	333—9
3,201,722	8/1965	May et al.	333—84
3,270,298	8/1966	Seidel.	

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