DIRECTIONAL COUPLERS FOR MICROWAVE TRANSMISSION SYSTEMS

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This invention relates to microwave transmission systems and more particularly to coupling devices therefor.

In the copending application of D. D. Grieg-H. F. Englmann, Serial No. 227,896, filed May 23, 1951, a new principle of microwave transmission is disclosed with which the coupling devices of this invention are particularly applicable. The new system employs, usually, two conductors, one as a "ground conductor" and the other as a "line conductor" spaced close together in substantially parallel relation. The so-called "ground conductor," which may be at ground potential or some other given potential, is considerably wider than the line conductor so that the surface thereof provides in effect an image reflection of the line conductor, whereby the distribution of the electric and magnetic fields between the conductors is substantially the same as the distribution between one conductor and the neutral plane of a theoretically perfect, two-conductor parallel system. Microwaves are easily propagated by the TEM mode along this line-ground conductor system since the microwaves flow in the concentrated regions of the electromagnetic field bounded substantially by the opposed surfaces of the line and ground conductors.

One of the objects of this invention is to provide coupling devices for such lines for transfer of microwave energy to or from such lines.

Another object of this invention is to provide coupling devices which are directional in character; and a further object is to provide coupling devices that may be used for bi-directional coupling.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent by reference to the following description taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a plan view with parts broken away showing a transmission line-ground conductor system with one form of directional coupling device in accordance with the principles of this invention;

Fig. 2 is a view in side elevation with parts in section taken along line 3—3 of Fig. 1; and

Fig. 3 is a cross-sectional view taken along line 3—3 of Fig. 2; and

Fig. 4 is a diagrammatical illustration of a bi-directional coupling device.

Referring to Figs. 1, 2 and 3 of the drawings, the microwave transmission system illustrated is of the printed circuit type comprising a first or line conductor 1 and a second or ground conductor 2 with a layer of dielectric material 3 therebetween. The conductive material may be applied to the layer of insulation in the form of conductive paint or ink, or the conductive material may be chemically deposited sprayed through a stencil or dusted onto selected surfaces of the insulation according to known circuit printed techniques. If desired, conductive strips may be cut and applied by a die-stamping operation. Also, the line conductor of desired configuration may be obtained by etching a thin conductive coating on one surface of the layer of dielectric. Furthermore, conductive lines need not be applied to a layer of insulation but may be supported if desired, in spaced relation with respect to a sheet of conductive material forming the ground conductor.

The conductor 2, may comprise one of the walls of a chassis or other part of the electric apparatus with which or in which the transmission system is used. The ground conductor 2 may extend a considerable distance laterally with respect to the line conductor but for practical purposes the width of the ground conductor is preferably twice or three times the width of the line conductor. The purpose of having the ground conductor of a width two to three times greater than the width of the line conductor is to provide in effect an image reflection of the line conductor. Also, the conductive lines need not be applied to a layer of insulation but may be supported if desired, in spaced relation with respect to a sheet of conductive material forming the ground conductor. Furthermore, conductive lines need not be applied to a layer of insulation but may be supported if desired, in spaced relation with respect to a sheet of conductive material forming the ground conductor.

This dopamine transmission system is disclosed with which the coupling devices of this invention are particularly applicable. The new system employs, usually, two conductors, one as a "ground conductor" and the other as a "line conductor" spaced close together in substantially parallel relation. The so-called "ground conductor," which may be at ground potential or some other given potential, is considerably wider than the line conductor so that the surface thereof provides in effect an image reflection of the line conductor, whereby the distribution of the electric and magnetic fields between the conductors is substantially the same as the distribution between one conductor and the neutral plane of a theoretically perfect, two-conductor parallel system. Microwaves are easily propagated by the TEM mode along this line-ground conductor system since the microwaves flow in the concentrated regions of the electromagnetic field bounded substantially by the opposed surfaces of the line and ground conductors.

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In order to obtain the desired directive coupling with a minimum of reflection from the terminating end 10, an attenuator pad 11 is disposed adjacent the terminating portion 10. This pad is of a lossy conductive material. For disclosures of adjustable attenuating pads and other forms of fixed pads, reference may be had to the copending application of D. D. Greg, H. F. Englemann, J. A. Kostriza, Serial No. 229,172, filed May 31, 1951. As disclosed in this copending application, the attenuating pad may comprise a layer of lossy material coating the termination portion 10 or a pad of lossy material may underly the termination portion. The output line 12 of the directional coupling device is disposed at an angle to the section 9 for a short distance to avoid further coupling.

In Fig. 4, a bi-directional coupling arrangement is illustrated comprising a coupling conductor 13 disposed in parallel relationship to the line conductor 1 and of a length equal to a half wave-length, or a multiple thereof, of the mid-frequency of the microwave energy. The ends of the coupling circuit are disposed preferably at right angles to the line conductor 1 as indicated by the connections 14 and 15. For matching purposes the conductor 13 is preferably continued beyond the connections 14 and 15 a quarter wavelength at which point these extensions 16 and 17 are terminated by connections 18 and 19 to conductor 2. This coupling device may be applied by printed circuit technique or may comprise a separate conductor disposed in a desired spaced relation with respect to the conductors 1 and 2. Also one connection such as 14 may be omitted with or without, omission of grounded section 17, whereby a directional coupler is obtained, the remaining grounded quarter wave section 16 presenting a high impedance termination. Where the line 13 is a wire conductor it may be supported by the ground connections 18 and 19.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made by way of example only and not as a limitation to the scope of my invention, as set forth in the objects thereof and in the accompanying claims.

I claim:

1. A directional coupling device for microwave transmission systems comprising a planar sheet of solid dielectric material, a first planar conductor lying flat against and attached to one face of said sheet, a second planar conductor lying flat against and attached to the opposite face of said sheet, said conductors extending parallel to each other, said sheet spacing said conductors a fraction of a wavelength apart, said second conductor being at least twice as wide as said first conductor with the main portion of an electric field of a wave propagated along said first and second conductors being distributed between the opposed surfaces thereof, a third planar conductor lying flat against said one face of said sheet spaced from said first conductor, said third conductor having a first part of an electrical length substantially equal to half a wavelength or a multiple thereof at the mid-frequency of microwave energy propagated along said first and second conductors, and being substantially parallel to both said first and second conductors and spaced in close interacting relation thereto by said intermediate sheet, and a second part extending from one end of the first part of an angle to said first part and away from said first conductor and cooperating with said second conductor to provide an output lead for energy derived from a wave propagated in a given direction along said first and second conductors, said one end being on the side of said first part furthest away from the direction from which said wave approaches to thereby provide a forward coupler, and means providing a matching impedance adjacent the other end of said first part.

2. A coupling device according to claim 1, wherein said means providing a matching impedance includes a body of lossy conductive material disposed adjacent the other end of said first part.

3. A coupling device according to claim 1, wherein the length of said first part is greater than several wave-lengths of the frequency of the microwave energy propagated along said first and second conductors.

4. A coupling device according to claim 1, wherein said third conductor includes a third part extending from said other end of the first part at an angle to said first part and away from said first conductor and cooperating with said second conductor to provide a second output lead for energy derived from a wave propagated in a direction opposite said given direction along said first and second conductors and means providing a cooperating matching impedance adjacent said one end of said first part.

5. A coupling device according to claim 4, wherein both of said means for providing a matching impedance comprise extended portions of said first part disposed beyond said second and third parts by a length equal substantially to a quarter wavelength of the frequency of the microwave energy propagated along said first and second conductors, and means connecting the ends of said extensions to said second conductor.

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