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de Ronde

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[54] **DIRECTIONAL COUPLER COMPRISING DIFFERENT TRANSMISSION LINES ON OPPOSITE SIDES OF DIELECTRIC BOARD**

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[51] **Int. Cl.**..H01p 5/14

[58] **Field of Search**..333/10, 84 M

[56] **References Cited**

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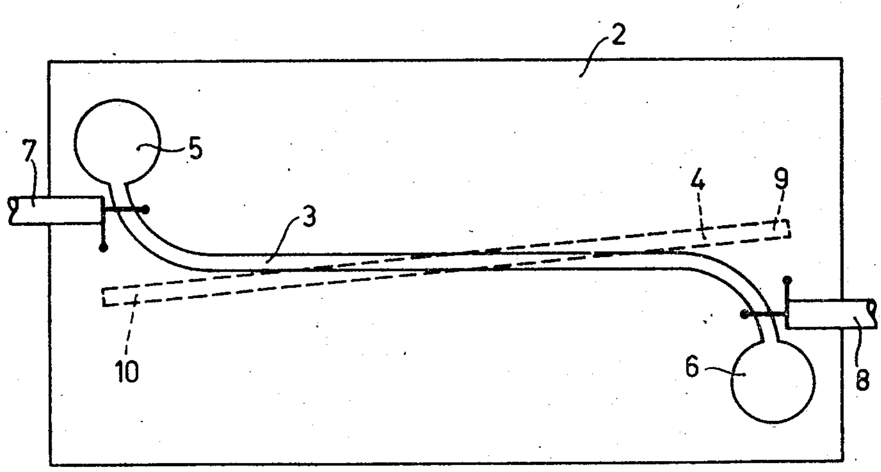
[57] **ABSTRACT**

A reciprocal directional coupling comprising a strip line provided on a dielectric supporting plate and a gap line provided on the opposite surface so that the longitudinal axes of the transmission lines cross each other at a small angle so that a wide, effective frequency bandwidth is obtained.

1 Claims, 3 Drawing Figures



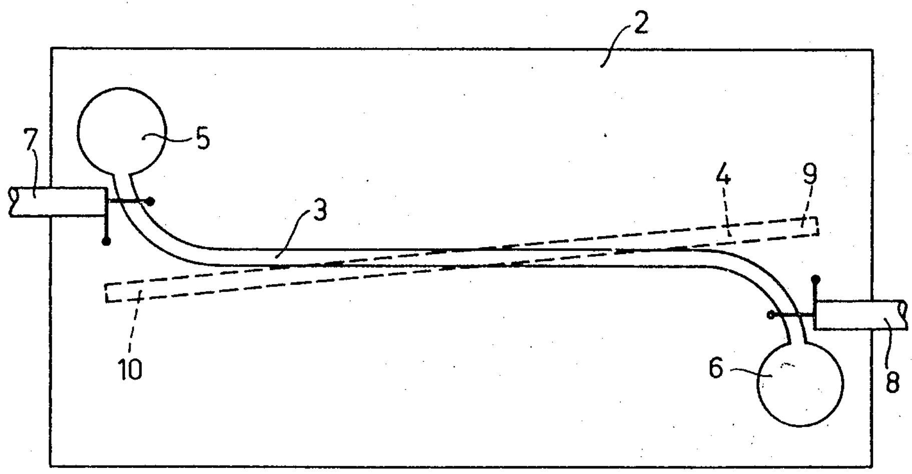


Fig.1

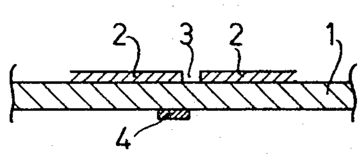


Fig.2a

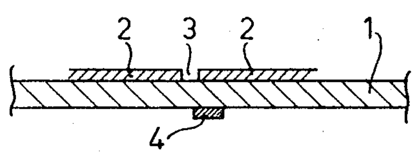


Fig.2b

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DIRECTIONAL COUPLER COMPRISING DIFFERENT TRANSMISSION LINES ON OPPOSITE SIDES OF DIELECTRIC BOARD

The invention relates to a reciprocal directional coupling. Such directional couplings usually comprise two relatively coupled transmission lines or waveguides whose four terminals in total form coupling points. Directional couplings have the property that wave energy fed to one terminal of one transmission line can be conducted away at least partly only via one of the terminals of the other transmission line and cannot be conducted via the other terminal of the other transmission line. Likewise wave energy fed to the other terminal of the first transmission line can be coupled out only via the other terminal of the second transmission line. These couplings are reciprocal.

Such directional couplings are employed, for example, for coupling out energy from a continuous transmission line, for example, in television distribution systems. In this case one of the coupling points may be connected to a television receiver and a further coupling point may be connected to a load resistor, in which normally no energy is dissipated. In general, this resistor is integral with the directional coupling.

There are known directional couplings in which a plurality of openings are provided in a common wall between two waveguides. When the high-frequency wave is coupled out at the terminal of one waveguide, energy is transferred at each opening to the other waveguide so that at each opening a secondary wave is produced in the other waveguide both in the forward direction and in the reverse direction. The waves in the forward direction have equal phases and support each other, whereas the waves in the reverse direction have different phases due to transit-time differences so that they will compensate one another on an average. The result is that at the terminal of the other waveguide which corresponds with the terminal of the first waveguide, where energy is coupled in, no energy can be coupled out, whereas energy can be coupled out at the remote terminal of the second waveguide. Although such directional couplings may be made to cover very wide bands, they are only suitable for use at a very high frequency.

For low frequencies it is therefore common practice to use directional couplings comprising two conductors arranged on a dielectric support and extending parallel to each other over a given distance. Between these conductors an electric coupling and a magnetic coupling are established so that in the forward direction the couplings compensate each other and in the reverse direction they support each other. Consequently, in contrast to the aforesaid directional coupling no energy is transferred from one conductor to the other in the forward direction, whereas energy is transferred in the reverse direction. However, due to the different transit times phase difference will appear between the waved coupled over at the respective places along the line so that as a whole the coupling intimately depends upon frequency, which means that the coupling is at a maximum when the length of the conductors is an odd multiple of one-quarter wavelength and is equal to zero when the length is an even multiple of one-quarter wavelength.

The invention provides a directional coupling whose coupling factor is substantially constant in a very wide frequency range, for example, between 1 and 10 gHz. The directional coupling according to the invention comprises two relatively coupled transmission lines arranged on opposite faces of a dielectric support, the coupling points being formed by the terminals of the transmission lines. According to the invention one transmission line is formed by a strip line constituted by an electric conductor on one surface of the support, whereas the other transmission line is a gap line formed by the gap between two electrically conductive faces on the other side of the support, while the longitudinal axis of the conductor, at least in the proximity of the gap, is at a small angle differing from zero to the longitudinal axis of the gap. The effect of the directional coupling is based on a difference of properties between strip lines and gap lines, which are known per se.

With a strip line or tape line both the electrical and magnetic lines of force mainly extend in planes at right angles to the longitudinal axes of the transmission lines.

On the contrary, with gap lines (as described, for example, in M. T. T. Symp. Dallas May 1969, pages 106, 107) only the electrical lines of force extend in a plane at right angles to the longitudinal axis of the transmission line, whereas the magnetic lines of force are located in planes parallel to the longitudinal axis and at right angles to the conductive faces where the gap is formed. Gap lines are essentially symmetric transmission lines and coupling occurs between the two conductive faces on either side of the gap.

When a strip line and a gap line are arranged parallel to each other, no coupling occurs between the lines, in contrast to the normal case of parallel conductors, because the magnetic lines of force are at right angles to each other. If the lines cross each other at right angles, a strong coupling is obtained, because the magnetic lines of force of the strip line are parallel to those of the gap line in the gap. This coupling is symmetrical and no directional effect is obtained.

If, however, the two lines cross each other at a small angle, the magnetic lines of force are not exactly at right angles to each other so that a coupling is left. Therefore, at various points along the lines within the trajectory of coupling energy will be transferred from one line to the other. With the waves in the forward direction the partial couplings will support each other. Although the energy transferred per unit of length is small, whereas on the other hand the trajectory of coupling is long, the overall coupling is yet strong, i.e., about equal to that in the case of lines crossing each other at right angles.

For waves in the reverse direction the coupling is destructive, like in the aforesaid waveguide directional coupling, which means that due to the phase differences resulting from differences in transit time the various partial couplings counteract each other so that the waves will cancel each other. The coupling in the reverse direction is of a periodical character as a function of the frequency and at the maximum it is equal to the energy coupled over a coupling length of one-quarter wavelength. According as the angle between the two transmission lines is smaller and hence the coupling trajectory is longer (particularly a higher number of wavelengths), the overcoupled energy per quarter wavelength will be lower and hence the coupling in the undesired direction is weaker.

The drawing shows schematically one embodiment of a directional coupling in accordance with the invention.

FIG. 1 is a plan view on the side of the gap line, whereas FIGS. 2*a* and 2*b* are partial cross-sectional views at various places along the line at right angles to the longitudinal axis.

A sheetlike support 1 of dielectric material is provided with a thin conductive layer 2 having a narrow gap 3. The width of this gap may be a few 10 microns. On the other side of the support 1 a conductive strip 4 is provided, which crosses the gap 3 at a very small angle so that a long coupling trajectory is formed. The gap 3 terminates at both ends in recesses 5 and 6. The gap transmission line 3 is coupled at the terminals with concentric transmission lines 7 and 8, the outer sheaths and the inner conductors of which are connected to the conductive layer 2 at points on either side of the gap 3. Such a coupling of a gap line with a different transmission line is known per se, but it may, of course, be replaced by a different type.

The recesses 5 and 6 form a high impedance between the coupling points. If desired, the tap may extend as far as to the edges of the conductive layer 2. The terminals of the strip line 4 may be coupled with concentric conductors (not shown), the inner conductors being connected to the terminals of the strip 4 and the outer conductors being connected to the conductive layer 2. If desired, the terminals may be coupled with a different type of transmission line, for example, a different strip line.

When, for example, a wave is fed via the concentric conductor 7, energy is coupled out to the output 9 of the strip 4, whereas the terminal 10 is practically insulated.

In a practical embodiment the coupling factor was equal to about −10 db. in a frequency range from 1 to 12 gHz., the maximum deviation being about 0.2 db. whereas the insulated output was more than 18 db. lower. The standing-wave ratio at the coupling-in conductor was lower than 1.10. The dimensions of the substrate were 1×2 feet.

The coupling factor depends inter alia upon the thickness of the dielectric intermediate layer. If this layer is sufficiently thin, a coupling factor of −3 db. can be easily attained.

The coupling length is preferably greater than 5 wavelengths.

What is claimed is:

1. A reciprocal directional coupling comprising two relatively coupled transmission lines arranged on opposite faces of a dielectric support, the coupling points being formed by the terminals of the transmission lines, characterized in that one transmission line is a strip line formed by an electric conductor on one face of the support and the other transmission line is a gap line formed by the gap between two electrically conductive surfaces on the other side of the support, the longitudinal axis of the conductor, at least in the proximity of the gap, being at a small angle differing from zero to the longitudinal axis of the gap.

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