

[54] **DIRECTIONAL FILTER USING MEANDER LINES**

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[51] Int. Cl. H01p 5/14, H01p 3/08, H03h 7/46

[58] Field of Search 333/70 S, 10, 84,
333/84 M

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[57]

ABSTRACT

A frequency-selective directional coupler is provided which comprises a fast-wave transmission line placed in proximity to a slow-wave transmission line. The fast wave line can be a waveguide, strip-line, or microstrip line which follows a fairly direct path between two points. The slow wave line can be a helix or a meander line.

8 Claims, 12 Drawing Figures

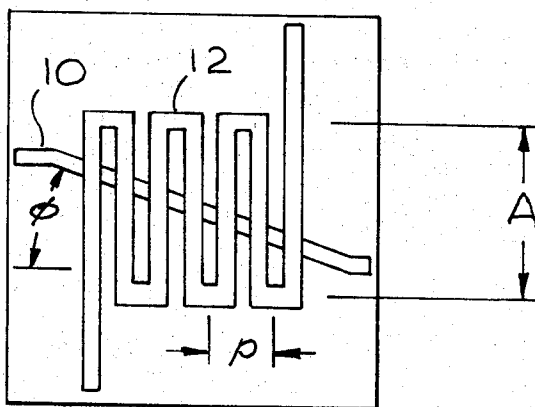


Fig. 1

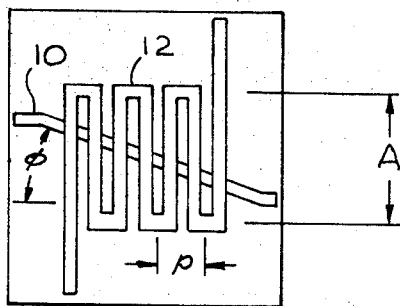


Fig. 1A

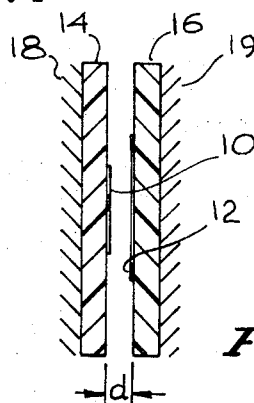


Fig. 2

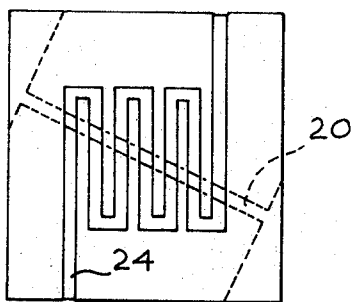


Fig. 2A

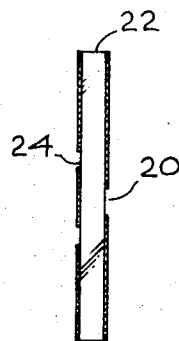


Fig. 3

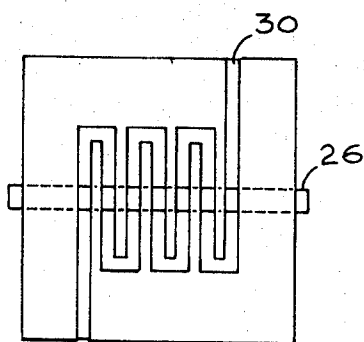


Fig. 3A

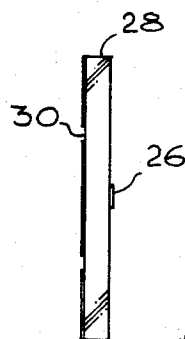


Fig. 4

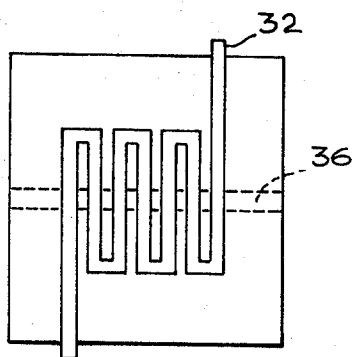
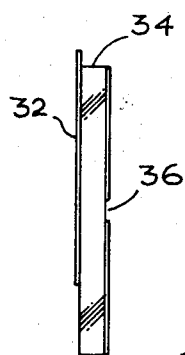


Fig. 4A



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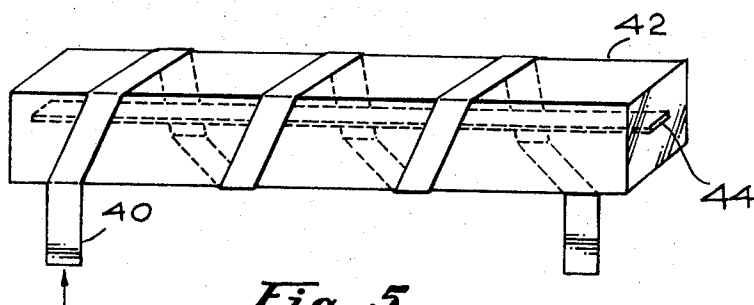


Fig. 5

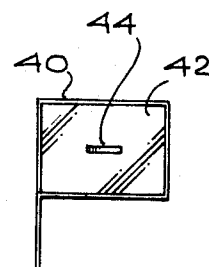


Fig. 5A

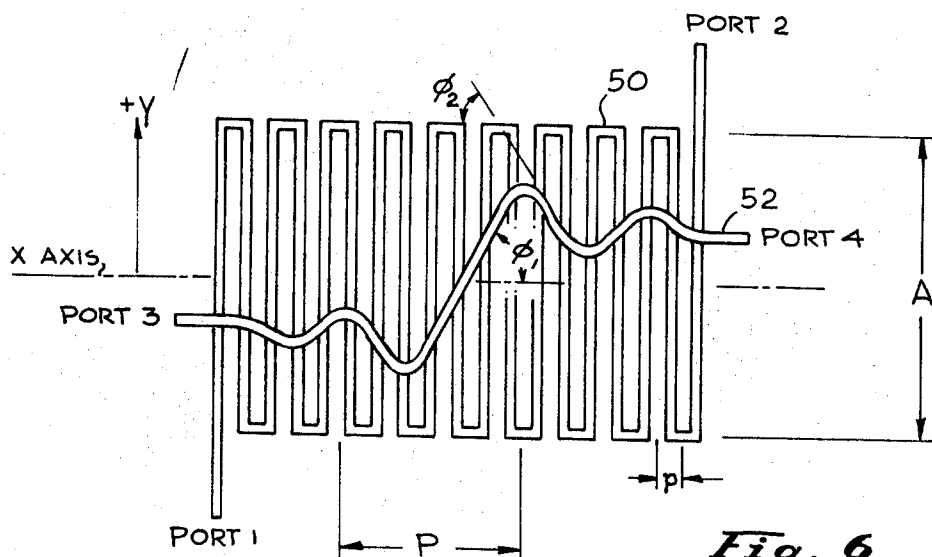


Fig. 6

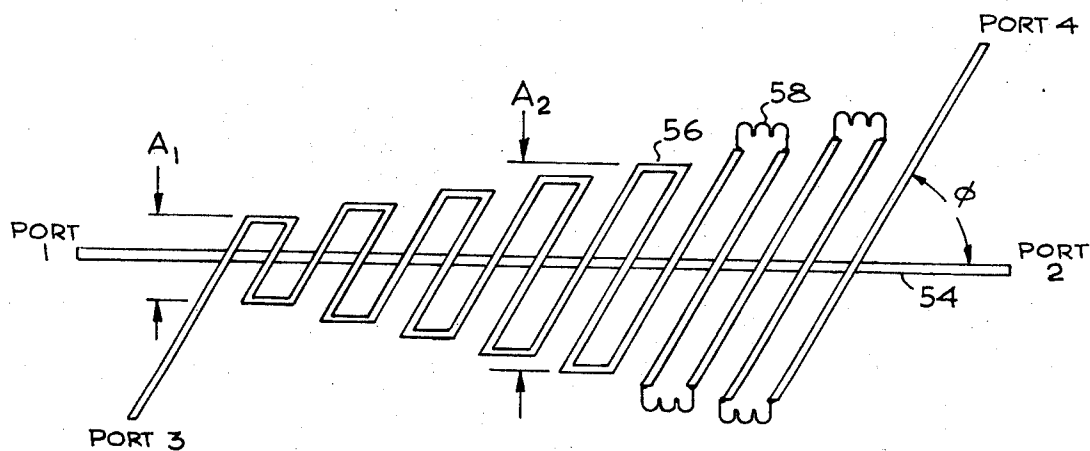


Fig. 7

DIRECTIONAL FILTER USING MEANDER LINES

BACKGROUND OF THE INVENTION

This invention relates to high frequency directional filters and more particularly to improvements therein.

Presently known directional filters (usually used for channel adding or dropping), commonly couple together strip lines (or microstrip) through the intermediary of a resonant loop, also in stripline. Due to difficulties of getting tight enough couplings it is hard to get broad bandwidth. To shape the band response curve, several loops are needed and the result is very bulky and lossy, (due to the low Q of the loops).

OBJECTS AND SUMMARY OF THE INVENTION

An object of this invention is to provide a directional filter of the general type described, which is not bulky or lossy.

Yet another object of the present invention is the provision of a directional filter of the type described which is much less expensive to construct and is much more compact.

Still another object of the present invention is the provision of a unique and novel directional filter of the type described.

These and other objects of the invention may be achieved in an arrangement wherein a fast wave transmission line is placed sufficiently close to a slow wave (periodic) transmission line so that there is electromagnetic coupling between the two.

The slow wave line is a helix or a meander line and the coupling is cumulative over the several periods of the helix or meander used. Further, the coupling is frequency selective according to the helix circumference or meander width. With four ports available there is a choice between two ports for connecting to the channel to be added or dropped, corresponding to co-flow and counter-flow couplings (the unused port is usually terminated).

The novel features of the invention are set forth with particularity in the appended claims. The invention will best be understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a directional filter in accordance with this invention, illustrating how a meandering strip, or slow-wave, line overlies the fast wave line; and

FIG. 1A is a side view of the arrangement shown in FIG. 1.

FIG. 2 is a directional filter in accordance with this invention illustrating coupled straight and meandered "slot" lines; and

FIG. 2A is a side view of FIG. 1.

FIG. 3 is a directional filter in accordance with this invention illustrating a straight strip line coupled to a meandered slot line; and

FIG. 3A is a side view of FIG. 3.

FIG. 4 illustrates a directional filter in accordance with this invention wherein a straight slot line is coupled to a meandered strip line; and

FIG. 4A is a side view of FIG. 4.

FIG. 5 illustrates a directional filter using a coupled straight and helical strip line; and

FIG. 5A is a side view of FIG. 5.

FIG. 6 is a schematical view illustrating a directional coupler in accordance with this invention which provides a very rectangular filter characteristic curve.

FIG. 7 is a schematic view of a strip line to strip line meandered coupler which provides an extremely broad bandwidth.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGS. 1 and 1A, there may be seen a schematic and side view of a directional filter in accordance with this invention, which comprises a fast wave strip line 10, coupled to a slow wave meander line 12. Both lines are strip lines. FIG. 1 effectively is a schematic view, since as may be seen from FIG. 1A, both strip lines are deposited on substrates respectively 14, 16, which are placed sufficiently close to one another to permit electromagnetic coupling to occur between the lines.

The substrates are shown only in outline in FIG. 1. The respective substrates which are made of dielectric material, are supported on ground planes respectively 18, 19.

To achieve coupling the fast wave strip line must run at an angle ϕ to the axis of the meander line and coupling should increase with an increase in ϕ and with a decrease in the spacing d , shown in FIG. 1A. The number of elements in the meander will affect both the coupling and the bandwidth. By varying the dimensions of A and p as shown on the drawings, from one element of the meander to the other, (i.e., "stagger tuning"), in combination with the choice of the number of elements, the shape of the band response curve, as well as its width, can be tailored. This is illustrated in FIGS. 6 and 7. Also, the angle ϕ may be varied to follow a curve of $(\sin x/x)dx$. This is also shown in FIG. 6.

The considerations just described also apply to the directional filter of FIG. 2 and 2A, which illustrate the manner of coupling straight and meandered slot lines. The straight line slot 20 is on one side of a dielectric substrate 22, and the meander slot, 24, is on the other side of the substrate 22. The substrate is thin enough to allow electromagnetic coupling. The slots are defined by the spacing between conductive regions.

FIGS. 3 and 4 show directional filters in which one transmission line is a strip (or microstrip), while the other is a "slot line." The advantages of these latter two structures include the fact that strong coupling can be obtained without resort to an angular orientation (i.e., ϕ equals zero). The straight strip line 26 in FIGS. 3 and 3A is deposited on one side of a substrate 28 and the meander slot line 30 is deposited on the other side of the substrate 28.

In FIGS. 4 and 4A, the meander strip line 32 is deposited on one side of the substrate 34 and the slot line 36 which is the straight line or fast wave transmission line is deposited on the other side of the substrate 34.

FIG. 5 is a schematic of a helical strip line coupled to a straight path line, and FIG. 5A is a side view thereof. The helical line 40, as may be seen in FIG. 5A, is deposited on a dielectric support 42, through the center of which the fast line 44 passes. The straight, fast line would not in general be concentric with or parallel to the axis of the helix, though drawn as such here to simplify the drawing.

For co-flow coupling with a helix, the center frequencies of coupled bands are lowered, (due to doppler

shift) by the factor $1 - v/c$ where v is the phase velocity on the slow wave structure; c represents the speed of light. With counterflow coupling, the power coupled increases monotonically as the coupling is tightened, while with co-flow couplings the power coupled varies cyclically (between zero and full coupling) with tightness of coupling (for a constant device length).

FIG. 6 shows a strip line to strip line coupler that gives a very rectangular filter characteristic. One of the transmission lines is a uniform strip line meander 50, similar to the types previously described. The second strip transmission line 52, is located above the meander line and has an undulating shaped path according to the function $y = \int (\sin x/x) dx$ where y represents the distance in an orthogonal direction above or below the x axis which is the symmetrical axis of the meander line 50.

As a result, the coupling coefficient along the X axis varies as $(\sin x/x)$. Because this function is the Fourier integral of the desired (rectangular) frequency response function, the desired frequency response should be obtained. FIG. 6 may be considered as a special case of FIG. 1, wherein ϕ is varied along the device length according to a program to give a desired frequency response.

FIG. 7 is a schematic diagram of a straight strip line (54) to meandered strip line (56) coupler, which may provide an extremely broad bandwidth. This may be considered a special case of the structure shown in FIG. 1, wherein the frequency determining dimension A is varied according to a program over an extremely broad range. For example, at the left end, A_1 , is made small enough to give coupling at that location around the X band (10GHZ). In the middle, the dimension A_2 may be larger to give the coupling needed at L band, (1 GHZ). At the right end coupling is obtained at 100 MHZ. However, instead of making the dimension A correspondingly larger at the right end, space may be saved by adding lumped inductances 58, which take the place of the truncated loops at the low frequencies.

There has accordingly been described herein, a novel and useful directional filter which can be made to have desired frequency characteristics and bandwidth.

What is claimed is:

1. A frequency selective directional coupler arrangement comprising an insulating substrate, fast wave transmission line means deposited on one side of said substrate, and slow wave transmission line means deposited on the other side of said substrate and overlying said fast wave transmission line means, said slow wave transmission line means having a predetermined pattern which crosses and recrosses the path of said fast wave transmission line means a plurality of times to provide a desired frequency response on the part of one of said transmission line means to signals applied to the other of said transmission line means, said insulating substrate being sufficiently thin to enable electromagnetic coupling between said fast and said slow transmission line means.
2. A frequency selective directional coupler arrangement as recited in claim 1 wherein said slow wave transmission line has a helical pattern.
3. A frequency selective directional coupler arrangement as recited in claim 1 wherein said slow wave transmission line has a meander line pattern.

4. A frequency selective directional coupler arrangement as recited in claim 1 wherein said fast wave transmission line has the pattern of substantially a straight line.

5. A frequency selective directional coupler as recited in claim 1 wherein said fast wave transmission line has a curved pattern.

6. A frequency selective directional coupler arrangement comprising:

a fast wave transmission line, and

a slow wave transmission line adjacent to, and electromagnetically coupled to said fast wave transmission line,

said slow wave transmission line having a regular grid pattern with a symmetrical x axis passing through the center of said grid pattern, and a y axis orthogonal thereto,

said fast wave transmission line having a pattern which follows the function

$$y = \int (\sin x/x) dx,$$

the paths of said fast and slow wave transmission lines relatively crossing and recrossing one another a plurality of times to provide a desired frequency response on the part of one of said transmission lines to signals applied to the other of said transmission lines.

7. A frequency selective directional coupler arrangement comprising:

a fast wave transmission line, and

a slow wave transmission line adjacent to, and electromagnetically coupled to said fast wave transmission line,

said slow wave transmission line having a grid pattern with a symmetrical x axis passing through the center of said grid pattern, and a y axis orthogonal thereto, said grid pattern increasing in size in the direction of said y axis as it extends along said x axis,

said fast wave transmission line extending along said x axis, and

the paths of said fast and slow wave transmission lines crossing and recrossing one another a plurality of times to provide a desired frequency response on the part of one of said transmission lines to signals applied to the other of said transmission lines.

8. A frequency selective directional coupler arrangement comprising:

a first substrate having a flat face,

a second substrate having a flat face which is parallel to, and spaced a predetermined distance from the flat face of said first substrate,

a fast wave transmission line means deposited on the flat face of said first substrate,

a slow wave transmission line means deposited on the flat face of said second substrate opposite to the location of the deposit on said first substrate of said fast wave transmission line means,

said slow wave transmission line means having a predetermined pattern which crosses and recrosses the path of said fast wave transmission line means a plurality of times to provide a desired frequency response on the part of one of said transmission line means to signals applied to the other of said transmission line means, and

the spacing between said first and second substrates being sufficiently close to enable electromagnetic coupling between said fast and said slow transmission line means.

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