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2,866,167

MICROWAVE SWITCH

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Fig. 1

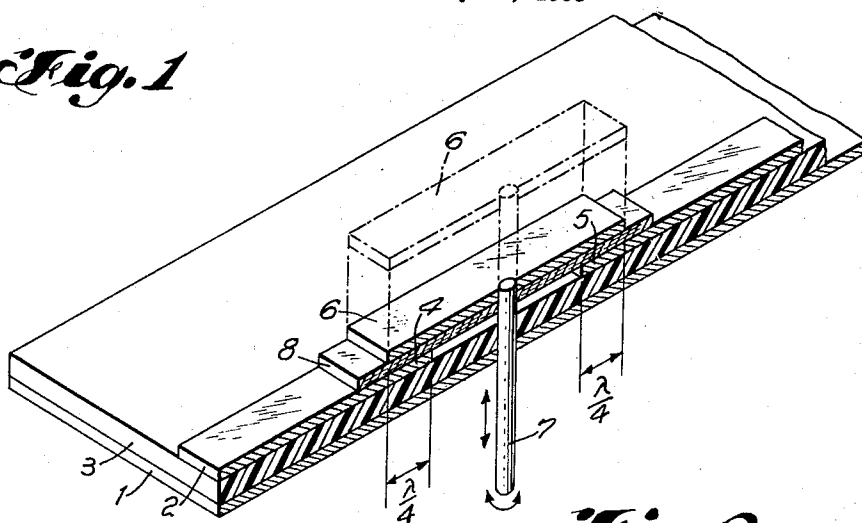


Fig. 2

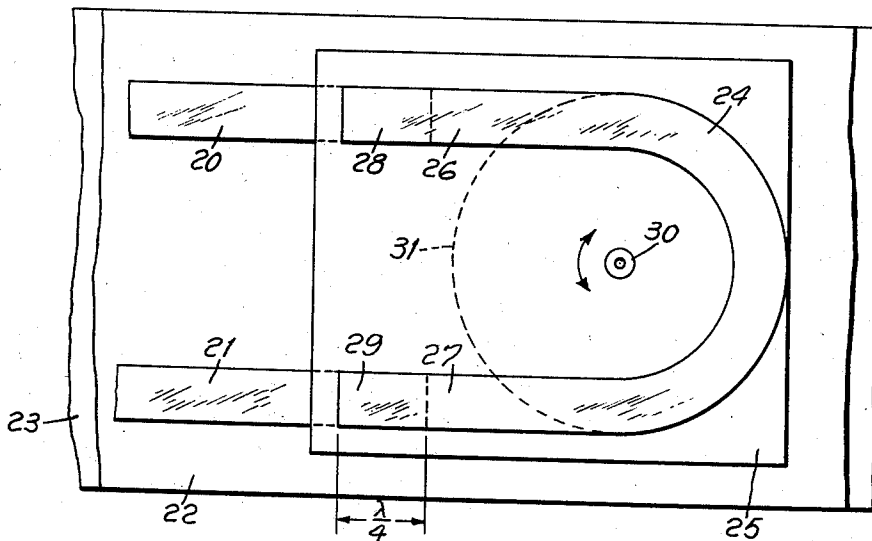
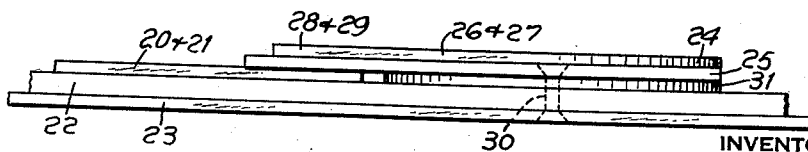


Fig. 3



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2,866,167

MICROWAVE SWITCH

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2 Claims. (Cl. 333—97)

This invention relates to switches for microwave transmission lines, and more particularly to switches for use in printed lines such as microstrip transmission lines.

Microstrip transmission lines comprise generally a line-above-ground type of transmission line over which microwave energy may be propagated in a mode approximating a TEM mode. In this type of transmission line a planar conductor is employed as a ground conductor, with a line conductor disposed in spaced parallel relationship thereto, generally by means of a strip or layer of dielectric material. The line and planar conductors are preferably of different widths, the planar conductor being made wider than the line conductor so that it appears as an infinite conducting surface to the line conductor. In this manner an electric field distribution is obtained characterized approximately by the TEM mode. Thus, the field distribution is believed to be similar to that which occurs between one of the conductors of a truly parallel conductor system and the neutral plane between such conductors. The important parameters of this type of transmission line are the width of the line conductor and the dielectric spacing between the line conductor and the planar conductor.

An important problem that arises in the use of these microwave transmission lines relates to the obtaining of switching devices to interrupt electromagnetic wave energy propagated through these transmission lines. If the line or strip conductor is broken and a metallic switching element is used to connect the broken end portions of the strip, poor electrical continuity results for the transmission of energy at microwave frequencies because of unequal contact pressures obtained between the overlapping metallic element and the end portions of the strip. Because of this, coupling mismatches occur and the resultant transmission line is extremely noisy and unserviceable. In the open position of the switch, higher order mode coupling tends to be present.

One of the objects of this invention, therefore, is to provide a suitable cut-off attenuator for switching electromagnetic wave energy in a microstrip transmission line.

It is an additional object to provide such an attenuator wherein spurious effects resulting from higher order mode coupling are substantially eliminated.

One of the features of this invention is the provision of a switch for a microwave transmission line wherein the line conductor is broken and transmission is re-established through use of non-contacting chokes at the end portions of the line conductor.

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 perspective view, partly in section, of a microwave transmission line of the line-above-ground type, incorporating a switch in accordance with the principles of this invention;

Fig. 2 is a plan view of an embodiment of a microwave

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switch of this invention for minimizing higher order mode coupling; and,

Fig. 3 is a front elevational view of the switch shown in Fig. 2.

Referring to Fig. 1, a microstrip transmission line is shown comprising a planar or ground conductor 1 and a planar line conductor 2, the conductors being spaced apart in substantially parallel relation by a thin strip or layer of dielectric material 3. The thickness of this dielectric layer is preferably a small fraction of the wavelength of the electromagnetic energy propagated therealong. The conductors 1 and 2 are preferably of flat strip form, the planar ground conductor being wider than the line conductor so that propagation of microwave energy therealong corresponds to the TEM mode as hereinbefore explained. The dielectric material may be of polystyrene, polyethylene, polytetrafluoroethylene, fiberglass, laminated fiberglass impregnated with polytetrafluoroethylene, quartz, or other suitable material of high dielectric quality. The conductors 1 and 2 may be formed on the dielectric strip by any of the known printed circuit techniques, one suitable method being a known electrolytic process. The strip or line conductor 2 is interrupted so that its end portions 4 and 5 are spaced apart at this interruption by a distance preferably greater than a wavelength of the energy transmitted therealong. The conductive switching element 6 is shown as a rectilinear metallic plate, preferably made of a high-conductivity material such as copper or silver. Upon movement of the dielectric rod 7 in a direction normal to the line 2, the switching element 6 may be raised or lowered with respect to this line and thereby be brought into an open or closed switching position, respectively. Between the conductive element 6 and the end portions 4 and 5 of the line conductor is a relatively thin layer of dielectric material 8, such as mica. This strip of dielectric material overlaps the end portions 4 and 5 of the line conductor 2 and may also extend beyond the conductive switching element 6. When the conductive switching element 6 is brought in closed position in parallel alignment with the line conductor 2, it serves to constitute a choke or an effective short for microwave energy at each end of the switching element. These chokes in the closed position of the switching element serve to complete the path for propagation of electromagnetic wave energy along the line conductor without being subject to the disadvantages heretofore encountered where metal contacts were used in direct contact with the line conductor for switching devices. This choke coupling is accomplished by having the end portions of the conductive element 6 overlap the end portions 4 and 5 of the line conductor 2 by a length equal to a quarter of a wavelength of the propagated energy therealong. It is readily apparent that lengths equal to integral odd multiples of a quarter wavelength will also serve to accomplish this coupling effect.

It has been found that for a vertical lifting of the non-contacting metal strip so as to provide a half inch gap, attenuations of the order of 25 decibels are obtained. It should be noted that the dielectric rod 7 may be rotated about its axis with the conductive rod 6 resting upon the dielectric layer 8; thus when this conductive element is at right angles to the line conductor 2, coupling is also thereby broken or at least greatly reduced.

While the switch shown in Fig. 1 is suitable for various programming requirements, because of the possibility of launching higher order modes at the coupling region, end-on coupling may result, thereby rendering the switch unsuitable for certain applications. In Figs. 2 and 3, a switching device is illustrated which may be used to correct or minimize such higher order mode coupling. Two substantially parallel line conductors 20 and 21

are disposed on a dielectric plate 22 in substantially parallel relation to the planar ground conductor 23 to form a microstrip transmission line. A horseshoe or U-shaped conductive switching element 24 is printed or otherwise disposed on a dielectric plate 25 such as mica, and this plate overlaps the line conductors 20 and 21. When the end portions 26 and 27 of the horseshoe-shaped conductive element are pivoted so that these end portions overlap the end portions 28 and 29, respectively, of the respective line conductors, the switch is in overlapped closed position, and the end portions of the switch overlap the end portions of the line conductors by a length equal to a quarter wavelength or an odd integral multiple thereof. Choke coupling is thus obtained, and in this closed position there is presented in effect an uninterrupted path for the propagation of energy along the microstrip transmission line. When the conductive element 24 is pivotally rotated by means of a pivot 30 so that end portions 26 and 27 are no longer in overlapping relation to end portions 28 and 29, the switch is then in open position and cutoff attenuation is obtained. It has been found that by breaking the circuit in this manner, higher order mode coupling is considerably reduced. Circular shoulder 31 made of a material of high dielectric quality is used to provide support and smooth rotation for plate 25 and conductive element 24.

It is apparent that many alternative switching devices may be realized in accordance with the objects and principles of this invention using known microstrip design techniques. Thus, while in Figs. 2 and 3 conductive element 24 has been shown as integrally rotatable with dielectric plate 25, it is of course realizable to have the dielectric plate 25 remain fixed and have only the conductive element 24 rotatable. In the copending application of Donald J. Le Vine, Serial No. 336,671, filed February 13, 1953, now Patent No. 2,836,798, assigned to the same assignee as this invention, design considerations with respect to the curvature of the bend shown in the horseshoe configuration are discussed. Also, in the copending application of John A. Kostiza and Paul Terranova, Serial No. 330,470, filed January 9, 1953, now Patent No. 2,797,390 and assigned to the same assignee as this invention, design considerations with respect to right angular bends and compensating tuning stubs are discussed for use with microstrip transmission circuitry. By reference to these two applications, it will be readily apparent to one skilled in this field that the horseshoe configuration may be replaced by two printed right angle bends and a coupling link therebetween may be pivotally rotated for opening and closing the circuit in accordance with the principles of this invention. Many similar embodiments may be equally well realized without departing from the basic principles and features of this invention, particularly with regard to interrupting the strip conductor for attenuation and re-establishing transmission by use of noncontacting chokes.

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 only by way of example 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 switch for a transmission line having a planar ground conductor, a line conductor and a layer of solid dielectric material disposing said conductors in spaced substantially parallel relation a fraction of the wavelength of the electrical energy propagated therealong, said line conductor having an interruption therein with the end portions of said line conductor spaced apart at said interruption and disposed in substantially parallel relation; comprising a horseshoe-shaped conductive switching element pivotally movable to open and closed positions and adapted to bridge said interruption and overlap said end portions when in closed position by a length equal to a quarter of the wave length or integral odd multiple thereof, a layer of solid dielectric material supporting said horseshoe-shaped conductor and pivotally movable therewith thereby constituting in conjunction with said element and said end portions a choke at each end of said element when said horseshoe-shaped switching element is in closed overlapping position to thereby present in effect an uninterrupted path for energy propagated along said line, the propagation of electrical energy along said line conductor being interrupted when said switching element is in open position, and means for pivotally moving said switching element and its supporting dielectric layer relative said open and closed positions.

2. A switch for a radio frequency transmission line having a planar ground conductor, a line conductor and means disposing the conductors in dielectrically spaced substantially parallel relation a fraction of the wavelength of the radio frequency energy propagated therealong, said line conductor having an interruption therein with the end portions of said line conductor spaced apart at said interruption, comprising a conductive switching element movable to open and closed positions and adapted to bridge said interruption and overlap said end portions when in closed position by a length equal to a quarter of the wave length or an integral odd multiple thereof, dielectric means interposed between said element and said overlapped end portions to constitute therewith a choke at each end of said element when said switching element is in closed position to thereby present in effect an uninterrupted path for energy propagated along said line, the propagation of electrical energy along said line conductor being interrupted when said switching element is in open position, means for moving said switching element relative said open and closed positions, the end portions of the line conductor defining the interruption in said line being disposed in substantially parallel relation and the conductive switching element being horseshoe-shaped and pivotally supported whereby the ends of the horseshoe may be moved to an overlapping closed position relative said parallel end portions of said line conductor and to an open non-overlapping position spaced apart from the end portions of said line conductor.

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