(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 126 811**
B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication of patent specification: **17.08.88**

(51) Int. Cl.[4]: **H 01 P 1/15**

(21) Application number: **83302922.6**

(22) Date of filing: **20.05.83**

(54) **Microwave switch.**

(43) Date of publication of application:
05.12.84 Bulletin 84/49

(45) Publication of the grant of the patent:
17.08.88 Bulletin 88/33

(84) Designated Contracting States:
DE FR IT SE

(56) References cited:
EP-A-0 073 165
FR-A-1 600 400
US-A-3 114 119
US-A-3 221 205

RADIO AND ELECTRONIC ENGINEER, vol. 52, no. 11/12, November/December 1982, pages 506-512, London, GBR.N. Bates et al.: "Millimetre-wave E-plane components and subsystems"

P.J. Meier: "Integrated Fin Line Millimeter Components, IEEE Transactions on Microwave Theory and Techniques, Vol. MTT-22, No. 12, Dec. 1974, pp. 1209-1216

(73) Proprietor: **THE MARCONI COMPANY LIMITED**
The Grove Warren Lane
Stanmore Middlesex HA7 4LY (GB)

(72) Inventor: **Greed, Robert Brian**
7, Coriander Road Tiptree
Colchester Essex, C05 0AS (GB)

(74) Representative: **Hoste, Colin Francis et al**
The General Electric Company p.l.c. Central Patent Department (Chelmsford Office) Marconi Research Centre West Hanningfield Road
Great Baddow Chelmsford CM2 8HN, Essex (GB)

Courier Press, Leamington Spa, England.

EP 0 126 811 B1

Description

This invention relates to a microwave switch which is suitable for controlling microwave energy in a waveguide system. It is particularly difficult to fabricate a microwave switch which is compatible with waveguide structures as this generally requires the provision of high precision moving parts. As an alternative, it has been proposed to utilise a fin line structure, as it is possible to electrically control the conductivity of such a structure without the need to provide mechanically movable parts. Switchable diodes can be used to short circuit opposing edges of a fin line structure, when it is required to render the switch non-conductive. Fin line structures are described in, for example, "Integrated Fin Line Millimeter Components" by P. J. Meier, IEEE Transactions on Microwave Theory and Techniques, Vol. MTT-22, No. 12, Dec. 74, pp. 1209 - 1206. Microwave switches which incorporate fin line structures have not been capable of providing a very high level of electrical performance and in particular in the off state, i.e. when the switch is nominally non-conductive, the impedance which it presents to an applied microwave signal is not sufficiently high for many purposes, as this can have the effect of allowing a relatively low level electrical signal to reach a load. Even though the level of this leakage signal is low, it is very undesirable and quite unacceptable for certain applications. The present invention seeks to provide an improved microwave switch in which this drawback is reduced.

According to this invention, a microwave switch for controlling the passage of microwave energy includes a waveguide channel dimensioned to support a predetermined waveguide mode of propagation of the microwave energy applied to it; a fin line structure, dimensioned to support a slot line mode of propagation, comprising a pair of co-planar conductive plates mounted across the waveguide channel and lying in the E plane, the two plates being spaced apart by a small distance; switchable means arranged to control the conductivity of the fin line structure; characterised by means for locally modifying the waveguide channel in the vicinity of the fin line structure so as to render said channel incapable of supporting said predetermined waveguide mode so that the microwave energy is diverted to said fin line structure.

Preferably the means for locally modifying the waveguide channel comprises a portion of the waveguide channel in which its height, in a direction perpendicular to the E plane direction, is very much reduced in the region of the fin line structure. This can be achieved by locally deforming the outer wall of the waveguide channel or alternatively by inserting into the channel a suitably shaped conductive plate or block. The presence of the means for locally modifying the waveguide channel prevents propagation of the fundamental waveguide mode and ensures that the applied microwave energy is diverted to the fin line structure so that it can be controlled by the switchable means by the switching arrangement.

Harmonic waveguide modes of propagation may be generated to a certain extent, although their amplitude as compared with that of the fundamental mode is very small as in a conventional switch utilising a fin line structure.

The means for locally modifying the waveguide channel also suppresses these harmonic modes. To further improve the attenuation of the harmonic modes, an absorbtive (lossy) material is mounted in cavities positioned in the vicinity of the fin line structure.

The switchable means can comprise one or more switchable diodes mounted to bridge the two plates of the fin line structure - these can be termed shunt mounted diodes. At relatively low microwave frequencies, microwave energy passes through the switch whilst the diode (or diodes) is non-conductive, whereas it is reflected back to the input port whilst the diode is held in its conductive state. Because all diodes possess inductance, the effect can be reversed at higher frequencies; that is to say, the switch is conductive whilst the diode is conductive and vice versa. Thus the switchable means has to be designed with the operating frequencies of the switch in mind.

Instead of using shunt mounted diodes, it is possible to mount one or more diodes to bridge discontinuities in one or both of the two plates which comprise the fin line structure. Such an arrangement of diodes is termed series mounted diodes.

The microwave switch can be used to route energy to different ones of a plurality of input or output ports, as opposed to operating as a simple on-off switch.

The invention is further described by way of example with reference to the accompanying drawings in which,

Figures 1 and 2 show sectional and perspective views respectively of a known microwave switch, and

Figure 3 shows a perspective view of a microwave switch in accordance with this invention, and

Figure 4 shows an alternative kind of switch.

Referring to Figure 1, which shows a sectional view, and Figure 2 which is an exploded perspective view, a microwave switch comprises two large blocks of conductive material 2 and 3 which are arranged to sandwich between them a fin line structure 4. Thin sheets of dielectric material 24, 25 are positioned on either side of the fin line structure 4, so as to electrically insulate it from the two blocks 2 and 3. In use, microwave energy is applied to an input port 5 of a microwave channel 6, which is dimensioned so as to support a predetermined waveguide mode of propagation. In this connection the term microwave includes millimetric frequencies. The fin line structure 4 consists of two coplanar plates 7 and 8 mounted in the E plane direction of the waveguide channel 6. For convenience the plates 7 and 8 are supported by the larger dielectric sheet 24. In some cases it may be more convenient to form the plates 7 and 8 respectively as thin conductive foils on opposite sides of a single thin insulating film of dielectric material - as the film is very thin, the two plates are still effeotively coplanar. The fin line has the effect of converting the waveguide mode of propagation to a slot line mode of propagation, and the two plates 7 and 8 are provided with edges surfaces 9 and 10 of a tapering profile adjacent to the input port 5 so as to avoid abrupt transitions occurring in the propagation of the microwave energy. Thus the microwave energy travels over the central portion of the fin line structure in a slot line mode, and is then progressively converted back to a waveguide mode of propagation by a further pair of tapering edges 11 and 12, so that the original waveguide mode of propagation is made available at an output port 13 of the waveguide channel 6.

Two diodes 14 and 15 are mounted so as to electrically bridge the two plates 7 and 8, and bias circuits 16 and 17 (which may include suitable filters) are arranged so as to permit the two diodes to be either biassed into conduction or non-conduction depending on the polarity and magnitude of bias voltages applied at contacts 18 and 19. If the two diodes 14 and 15 are held non-conductive, the microwave energy applied at input port 5 travels through the switch to a load (not shown) via port 6 with very little attenuation. However, if the two diodes are rendered conductive, the microwave energy is reflected back to its source and very little energy reaches the load. Additional diodes can be provided to enhance the switching action if needed.

To minimise the loss of microwave energy whilst the switch is in its conductive state, two r.f. choke circuits in the form of cavities 20 and 21 are provided. The thickness of the wall "T" is made equal to $\lambda/4$ where λ is the wavelength of the applied signal. These cavities operate to ensure the existence of an effective radio frequency short circuit between the fin line structure itself and the adjacent waveguide walls. Unfortunately, although these chokes are essential, their presence enables many more modes of propagation to exist. In particular, harmonic modes of propagation can now by-pass the fin line structure and reach a load even whilst the switch is nominally in its non-conductive state.

These leakage levels of microwave energy can be very small indeed, but are still unacceptable for certain applications. A microwave switch which is modified in accordance with this invention is illustrated in Figure 3, and it permits the performance level to be substantially enhanced to levels which enable very stringent performance requirements to be met.

Referring to Figure 3, the reference numerals of Figures 1 and 2 are used to identify like parts. The main point of difference shown in Figure 3 comprises two side wall blocks 30 mounted adjacent to the fin line structure (part of the cavity wall is cut away so that one block 30 can be seen, but the other block, which is mounted within the block 3, is not visible). Each block has a height which is somewhat less than the corresponding depth of the waveguide channel so that the tops of the blocks do not contact the fin line structure itself. Each end of each block 30 is tapered as shown, to give a more gradual transition to and from the slot line mode. Although in this example, both blocks 30 are electrically connected to the walls of the channels 6, they can be electrically insulated from it. Both blocks 30, are however, formed of a material having a good electrical conductivity. The presence of these blocks prevents propagation of the waveguide mode along the waveguide channel, and forces the microwave energy wholly into a slot line mode, so that it is conducted along the fin line structure. In this way virtually all of the energy applied to the switch is controlled by the action of the diodes 14 and 15.

Even so, some of the harmonic modes continue to exist and these can by-pass the fin line structure by passing along the choke cavities 20 and 21. Lossy absorbent material 33 and 34 is positioned in each choke cavity to absorb this energy and to prevent the excitation of harmonic modes of any appreciable energy. Similar blocks, not shown, are mounted in the waveguide structure 3 in an exactly analogous manner. Any suitable lossy material can be used, such as Marconi Absorber type Y33-1980.

The effect of the side wall blocks 30 and the lossy material is to very greatly enhance the performance of the switch. Although the conductivity of the switch in its "on" state remains very high, its effective transmissive impedance in the "off" state becomes very high indeed, and reduces energy leakage to a load of harmonic modes to an extremely low level.

A three port switch is shown in Figure 4. It has one input port 32, and two output ports 33 and 34. The general principle of operation is very similar to that of the switch shown in Figure 3, but three waveguide channels 35, 36, 37 meet at a point where a side wall block 38 is positioned. In Figure 4, only the bottom half of the switch structure is shown, and in practice an additional block is placed above that of the block 38, with a fin line structure between them. As before the block 38 has tapered ends 39, 40, 41. The fin line structure is shown in broken line - it consists of three plates 42, 43, 44, with the plates being bridged by switchable diodes 45, 46 placed in the two channels 36, 37 leading to the output ports 33, 34. By controlling the state of the diodes, microwave energy can be routed to either output port, or even shared between them. Absorbtive (lossy) material 47, 48, 49 is positioned in cavities 50, 51, 52 adjacent to the fin line structure, in a manner analogous to that of Figure 3.

Claims.

1. A microwave switch including a waveguide channel (6) dimensioned to support a predeter-

mined waveguide mode of propagation of the microwave energy applied to it; a fin line structure (4), dimensioned to support a slot line mode of propagation, comprising a pair of co-planar conductive plates (7,8) mounted across the waveguide channel and lying in the E plane, the two plates being spaced apart by a small distance; and switchable means (14, 15) arranged to control the conductivity of the switch, characterised by means (30) for locally modifying the waveguide channel in the vicinity of the fin line structure so as to render said channel incapable of supporting said predetermined waveguide mode so that the microwave energy is diverted to said fin line structure.

2. A switch as claimed in claim 1 and wherein the means for locally modifying the waveguide channel comprises a portion of the waveguide channel in which its height, in a direction perpendicular to the E plane direction, is very much reduced in the region of the fin line structure.

3. A switch as claimed in claim 2 and wherein the means for locally modifying the waveguide channel comprise a pair of conductive blocks, one mounted on either side of said fin line structure.

4. A switch as claimed in claim 3 and wherein the ends of the blocks are shaped so as to present tapered transition regions to the input and output ports of the switch.

5. A switch as claimed in claim 3 or 4 and wherein the blocks are electrically connected to the waveguide channel.

Patentanspruche

1. Mikrowellenschalter mit einem Wellenleiterkanal (6), der zur Unterstützung eines vorbestimmten Fortpflanzungsmodus im Wellenleiter der an ihm anliegenden Mikrowellenenergie dimensioniert ist, mit einer Flossenleitungsstruktur (4), die zur Unterstützung eines Schlitzleitungs-Fortpflanzungsmodus dimensioniert ist, mit zwei koplanaren leitenden Platten (7, 8), die über dem Wellenleiterkanal angebracht sind und in der E-Ebene liegen, wobei die beiden Platten voneinander einen kleinen Abstand besitzen, und mit schaltbaren Mitteln (14, 15), die zum Steuern der Leitfähigkeit des Schalters ausgelegt sind, gekennzeichnet durch Mittel zum örtlichen Modifizieren des Wellenleiterkanales in der Umgebung der Flossenleiterstruktur, um so den Kanal zum Unterstützen des vorbestimmten Wellenleitermodus unfähig zu machen, so daß die Mikrowellenenergie zu der Flossenleiterstruktur abgelenkt wird.

2. Schalter nach Anspruch 1 und bei dem die Mittel zum örtlichen Modifizieren des Wellenleiterkanales einen Abschnitt des Wellenleiterkanales umfassen, in welchem seine Höhe in senkrechter Richtung auf der E-Ebenen-Richtung sehr beträchtlich in dem Bereich der Flossenleiterstruktur reduziert ist.

3. Schalter nach Anspruch 2 und bei dem das Mittel zum örtlichen Modifizieren des Wellenleiterkanales zwei leitende Klötze umfaßt, die jeweils einzeln zu beiden Seiten der Flossenleiterstruktur angebracht sind.

4. Schalter nach Anspruch 3 und bei dem die Enden der Klötze so geformt sind, daß sie zu den Eingangs- bzw. Ausgangs-Anschlüssen des Schalters sich verjüngende Übergangsbereiche präsentieren.

5. Schalter nach Anspruch 3 oder 4 und bei dem die Klötze elektrisch mit dem Wellenleiterkanal verbunden sind.

Revendications

1. Commutateur pour micro-ondes comportant un canal guide d'ondes (6) dimensionné de façon à entretenir un mode de propagation de guide d'ondes prédéterminé pour l'énergie micro-onde qui lui est appliquée; une structure de ligne à ailette (4) dimensionnée de façon à entretenir un mode de propagation de ligne à fente, comprenant une paire de plaques conductrices coplanaires (7, 8) montée en travers du canal guide d'ondes et se trouvant dans le plan E, les deux plaques étant séparées l'une de l'autre d'une petite distance; et un moyen commutable (14, 15) disposé de façon à commander la conductivité du commutateur; caractérisé par un moyen (30) qui permet de modifier localement le canal guide d'ondes au voisinage de la structure de ligne à ailette afin de rendre ledit canal inapte à l'entretien dudit mode de guide d'ondes prédéterminé, si bien que l'énergie micro-onde est déviée sur ladite structure de ligne à ailette.

2. Commutateur selon la revendication 1, où le moyen permettant de modifier localement le canal guide d'ondes comprend une partie du canal guide d'ondes dont la hauteur, dans la direction perpendiculaire au plan E, est extrêmement réduite dans la région de la structure de ligne à ailette.

3. Commutateur selon la revendication 2, où le moyen permettant de modifier localement le canal guide d'ondes comprend une paire de blocs conducteurs, qui sont montés respectivement de part et d'autre de ladite structure de ligne à ailette.

4. Commutateur selon la revendication 3, où les extrémités des blocs sont conformées de manière à présenter des régions de transition allant en s'amincissant vers les orifices d'entrée et de sortie du commutateur.

5. Commutateur selon la revendication 3 ou 4, où les blocs sont électriquement connectés au canal guide d'ondes.

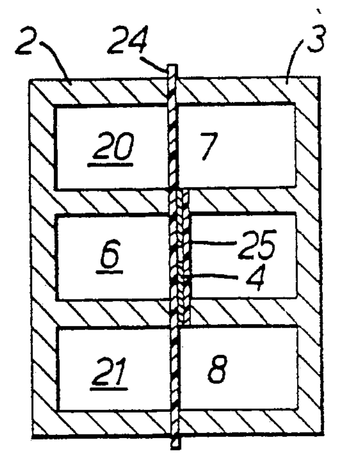
2
24
3
20
7
6
25
4
21
8

FIG. 1.

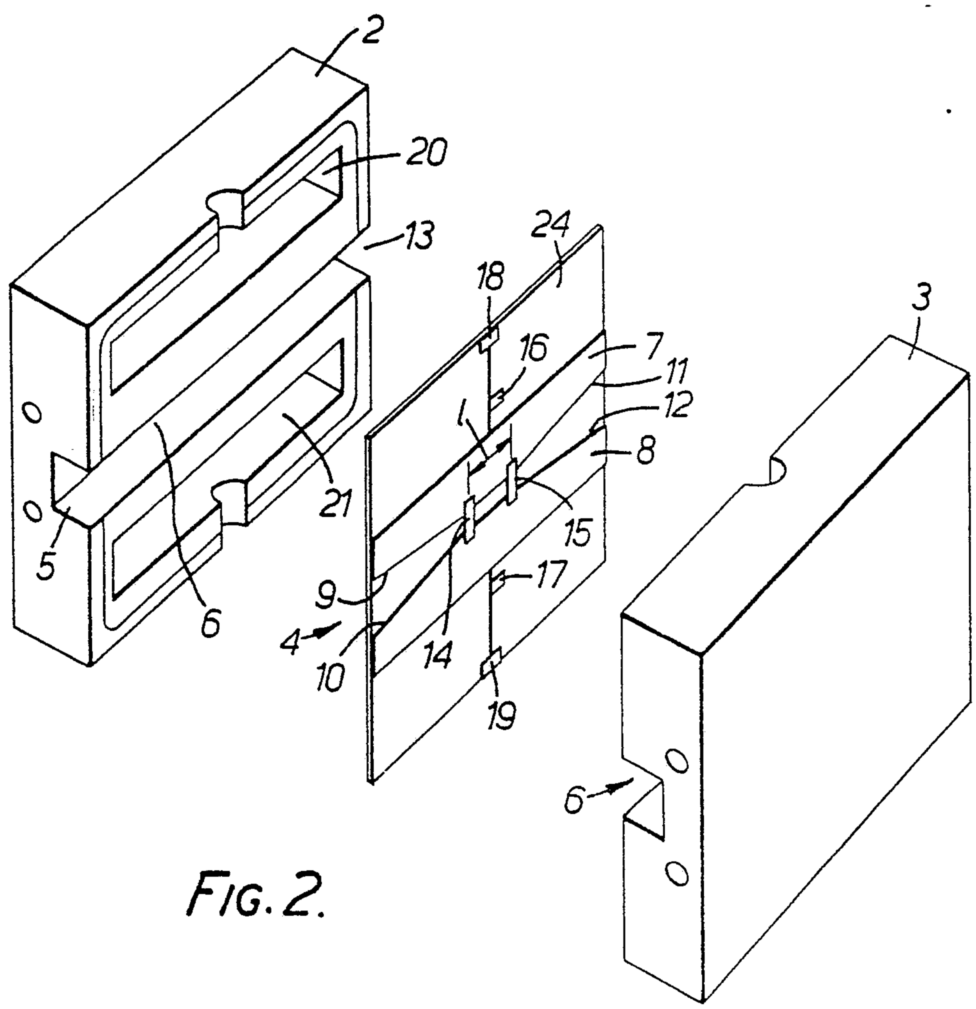
2
20
13
24
18
16
7
11
12
1
8
15
3
21
5
6
9
4
10
14
17
19
6

FIG. 2.

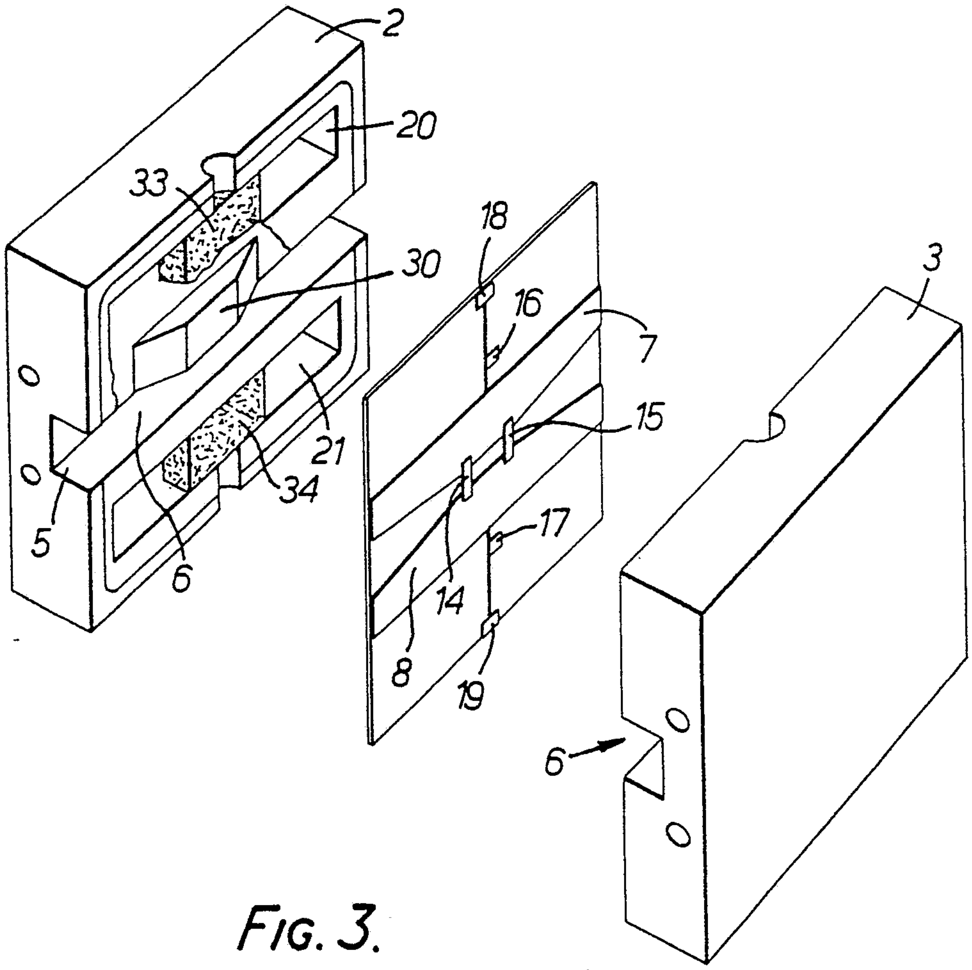
2
20
33
30
18
16
3
7
15
21
34
5
6
17
14
8
19
6

FIG. 3.

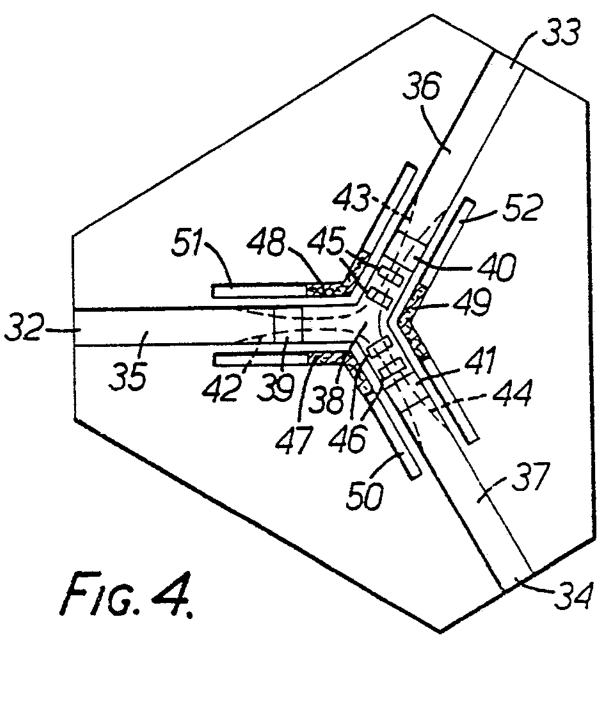
33
36
43
52
51
48
45
40
49
32
41
44
35
42
39
38
47
46
37
50
34

FIG. 4.