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(54) **Thin-film circulator with three matched gates.**

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PATENT ABSTRACTS OF JAPAN, vol. 4, no. 67 (E-11)[549], 20th May 1980, page 117 E 11; & JP-A-55 37 040 (TSUKASA NAGAO) 14-03-1980

IEEE TRANS. ON MICROWAVE THEORY & TECHN., vol. MTT-28, no. 6, June 1980, pages 616-621, IEEE, New York, US; J. HELSZAJN et al.: "Characteristics of circulators using planar triangular and disk resonators symmetrically loaded with magnetic ridges"

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Description

The present invention relates to a three-gate thin-film circulator with impedance matching.

A three-gate thin-film circulator is a device which when inserted in a transmission line makes the path nonreciprocal, i.e. not two-directional. If inserted in a microwave branching system said device permits conveyance to a single antenna of the signals of several transmitters or else distribution of signals from said antenna to appropriate receivers. If one of the three matched gates is closed on a matching termination the device ensures decoupling if placed between two microwave circuits or matching if inserted upstream from the circuit in question.

A known three-gate circulator is made at present with a substrate of magnetizable material formed of a garnet or ferrite disk entirely metallized on both sides and inserted in a special hole made in a dielectric substrate. Access thereto is through three transmission lines deposited on the dielectric substrate and arranged at 120° to each other. If a magnetizable substrate in circular form is not available, one of the sides of the magnetizable substrate is metallized with a circular geometry of appropriate diameter the access to which is likewise obtained with three transmission lines arranged at 120° on the magnetizable substrate.

Said known circulator has several shortcomings, specifically rather large space occupied linked to the diameter of the magnetizable substrate, the need to use impedance transformers to match output impedance to that of the circuit with which it is associated (with the resulting further increase in size) and finally the greater insertion losses introduced by the matching lines.

To overcome these shortcomings there has recently been accomplished a circulator for instance of the type disclosed in the German patent DE-A-2 401 188, in which metallization of the accessible face of the magnetizable substrate is no longer uniformly circular but divided in three distinct areas by narrow radial nonconducting segments 120° apart, the external edges of said areas constituting the input and output gates.

This metallization geometry made it possible to reduce the diameter of the magnetizable substrate and hence the space occupied by the device, transmission frequency being equal, but didn't solve the problem of matching. The operation of the circulator was also unsatisfactory.

The object of the present invention is accordingly to achieve a thin-film three-gate circulator which would occupy little space and display self-matching impedance characteristics such that no external adapters would be needed.

In accordance with the invention said object has been achieved by a circulator as defined in claim 1.

In other words the present invention takes as its starting point the known three-area circulator, reducing the extent of said areas in favor of the intervals between said areas, wherein there have been inserted respective line sections (stubs) having an impedance matching function. The result is a circulator made up of three transmission lines 120° apart provided with impedance matching units. The space occupied by the circulator is thus further reduced and the insertion losses otherwise caused by the external matching networks are eliminated.

Two practical examples of the accomplishment of the present invention are illustrated for greater clarity in the annexed drawings wherein -

FIG. 1 shows a plan view of a circulator in accordance with the invention made in circular form,

FIG. 2 shows a cross section along line II-II of FIG. 1 of said circular,

FIG. 3 shows a plan view of a circulator in accordance with the invention made in triangular form.

The circulator illustrated in FIGS. 1 and 2 comprises a substrate of magnetizable material 1 made in the form of a garnet or ferrite disc. One face thereof (the bottom face shown in the drawings) is completely coated with circular thin-film metallization 2, also called "ground plane", while the other face thereof (the top face in the drawings) has thin-film metallization of a more complex geometry describing the electrical circuit of the circulator described below.

As shown in FIG. 1 the metallization of the top face of the substrate 1 comprises three transmission lines 3 arranged 120° apart and converging at a common centre 4 from respective input and output gates 5 which pass through a circular non-metallized periphery of the substrate 1 which is not necessary for the electrical operation of the circulator and serves only to make clear the input and output gates 5 thereof.

Again as shown in FIG. 1 in the intervals between the transmission lines 3 are placed three more line sections 6 which come together in the common centre 4 and operate as impedance adaptors (stubs).

The conformation of the line sections 6, generally of uniform width up to a terminal narrowing 7 before the common centre 4, is such that the transmission lines 3 have in turn an innermost line portion 8 of uniform width (and hence impedance) and an outermost line portion 9 of non-uniform width (and hence impedance) in the direction of propagation. The outermost portion 9 communi-

cates with the corresponding input/output gate 5.

The circulator of FIGS. 1 and 2 is designed to be inserted in a dielectric substrate on which is made a microwave circuit and together therewith in a container in which there is also housed a magnet capable of supplying a steady magnetic field. This design is known in itself and is therefore not described and illustrated in detail here.

While it is essential that metallization of the top face (in the drawings) of the substrate 1 have the geometry described with the three transmission lines 3 and three matching line sections 6 it is not essential that said metallization and the circulator in general have a circular conformation. Alternatively there can be provided a triangular conformation like that shown in FIG. 3 where the same reference numbers as in FIGS. 1 and 2 are used to indicate corresponding parts.

Finally it should be noted that an alternative use of the circulator of FIGS. 1 and 2 or of the one shown in FIG. 3 can call for the deposit directly on the substrate 1 between a gate 5 and the ground plane 2 of a resistance having a value equal to that of the characteristic impedance of the circuit. In this case the circulator functions as a separator, offering low attenuation in one direction and high attenuation in the other.

Claims

1. Thin-film circulator with three gates comprising a substrate of magnetizable material (1) having one face provided with unbroken thin-film metallization (2) and another face provided with thin-film metallization having a geometry such as to describe three transmission lines (3) 120° apart converging at a common centre (4) from respective input and output gates (5) and comprising an outward part (9) of non-uniform width in the direction of propagation, said circulator further comprising three other line sections (6) of uniform width placed in the intervals between said transmission lines (3) and coming together at said common centre (4) to accomplish impedance matching of said input and output gates (5), characterized in that said matching line sections (6) of uniform width have narrowing ends (7) toward said common centre (4) and said transmission lines (3) have an inside part (8) of uniform width.
2. Circulator in accordance with claim 1 characterized in that said metallization (3-6) of the other face of the substrate (1) is circular in form.
3. Circulator in accordance with claim 1 characterized in that said metallization (3-6) of the

other face of the substrate (1) is of triangular form.

4. Circulator in accordance with claim 1 characterized in that it comprises a resistance of a value equal to that of the characteristic impedance of a microwave circuit with which it is associated, said resistance being placed on said substrate (1) between one of said gates (5) and said face (2) provided with unbroken thin-film metallization (2) such that the circulator functions as a separator.

Patentansprüche

1. Dünnschichtzirkulator mit drei Gattern und einem aus magnetisierbarem Material (1) bestehenden Substrat, dessen eine Oberfläche mit einer ununterbrochenen Dünnschichtmetallisierung (2) versehen ist und dessen andere Oberfläche mit einer Dünnschichtmetallisierung versehen ist, deren Geometrie drei Übertragungsleitungen (3) beschreibt, die, ausgehend von den zugehörigen Eingangs- und Ausgangsgattern (5), gegenseitig einen Winkel von 120° bilden, in einem gemeinsamen Zentralpunkt (4) zusammenkommen, und einen äußeren Teil (9) nicht einheitlicher Breite aufweisen, den erwähnten Zirkulator und außerdem drei Leitungsabschnitte (6) einheitlicher Breite mit einschließen, die in den Zwischenräumen der erwähnten Übertragungsleitungen (3) angebracht sind und zur Impedanzanpassung der erwähnten Eingangs- und Ausgangsgatter (5) in dem erwähnten gemeinsamen Zentralpunkt (4) zusammenkommen, **dadurch gekennzeichnet**, daß die erwähnten Leitungsanpassungsabschnitte (6) einheitlicher Breite verjüngte, zum gemeinsamen Zentralpunkt (4) weisende Enden (7) haben, und daß die erwähnten Übertragungsleitungen (3) in Ausbreitungsrichtung einen inneren Teil (8) einheitlicher Breite aufweisen.
2. Zirkulator in Übereinstimmung mit Anspruch 1, **dadurch gekennzeichnet**, daß die erwähnte Metallisierung (3-6) der anderen Oberfläche des Substrats (1) kreisförmig ist.
3. Zirkulator in Übereinstimmung mit Anspruch 1, **dadurch gekennzeichnet**, daß die erwähnte Metallisierung (3-6) der anderen Oberfläche des Substrats (1) eine dreieckige Form hat.
4. Zirkulator in Übereinstimmung mit Anspruch 1, **dadurch gekennzeichnet**, daß er einen Widerstand einschließt, mit einem Wert, der gleich der charakteristischen Impedanz einer zugehörigen Mikrowellenschaltung ist, wobei

der erwähnte Widerstand auf dem Substrat (1) zwischen einem der erwähnten Gatter (5) und der erwähnten, mit Dünnschicht-Metallisierung (2) versehenen Oberfläche (2) angebracht ist, so daß der Zirkulator wie ein Trennglied arbeitet. 5

Revendications

1. Circulateur à couches minces ayant trois accès, comprenant un substrat en un matériau magnétisable (1) dont une face est munie d'une métallisation (2) consistant en une couche mince ininterrompue, et une autre face est munie d'une métallisation à couche mince ayant une configuration géométrique qui définit trois lignes de transmission (3) écartées de 120° qui convergent en un centre commun (4), à partir d'accès d'entrée et de sortie respectifs (5), et comprenant une partie extérieure (9) de largeur non uniforme dans la direction de propagation, ce circulateur comprenant en outre trois autres sections de ligne (6) de largeur uniforme, placées dans les intervalles entre les lignes de transmission (3) et se rejoignant au centre commun (4) pour réaliser l'adaptation d'impédance des accès d'entrée et de sortie (5), caractérisé en ce que les sections de lignes d'adaptation (6) de largeur uniforme ont des extrémités (7) allant en se rétrécissant vers le centre commun (4), et les lignes de transmission (3) ont une partie intérieure (8) de largeur uniforme. 10
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2. Circulateur selon la revendication 1, caractérisé en ce que la métallisation (3-6) de l'autre face du substrat (1) a une forme circulaire. 35
3. Circulateur selon la revendication 1, caractérisé en ce que la métallisation (3-6) de l'autre face du substrat (1) a une forme triangulaire. 40
4. Circulateur selon la revendication 1, caractérisé en ce qu'il comprend une résistance d'une valeur égale à celle de l'impédance caractéristique d'un circuit micro-onde auquel il est associé, cette résistance étant placée sur le substrat (1) entre l'un des accès (5) et la face (2) qui est munie de la métallisation consistant en une couche mince ininterrompue (12), de façon que le circulateur fonctionne en séparateur. 45
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