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[54] **STRIPLINE THIN-FILM RESISTIVE TERMINATION WHEREIN CAPACITIVE REACTANCE CANCELS OUT UNDESIRE SERIES INDUCTANCE OF RESISTIVE FILM**
4 Claims, 1 Drawing Fig.

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[56]

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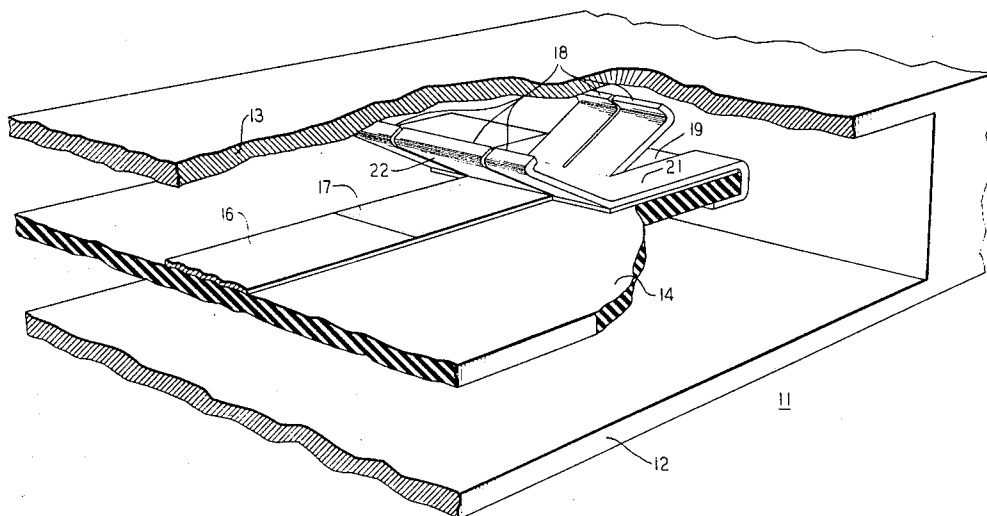
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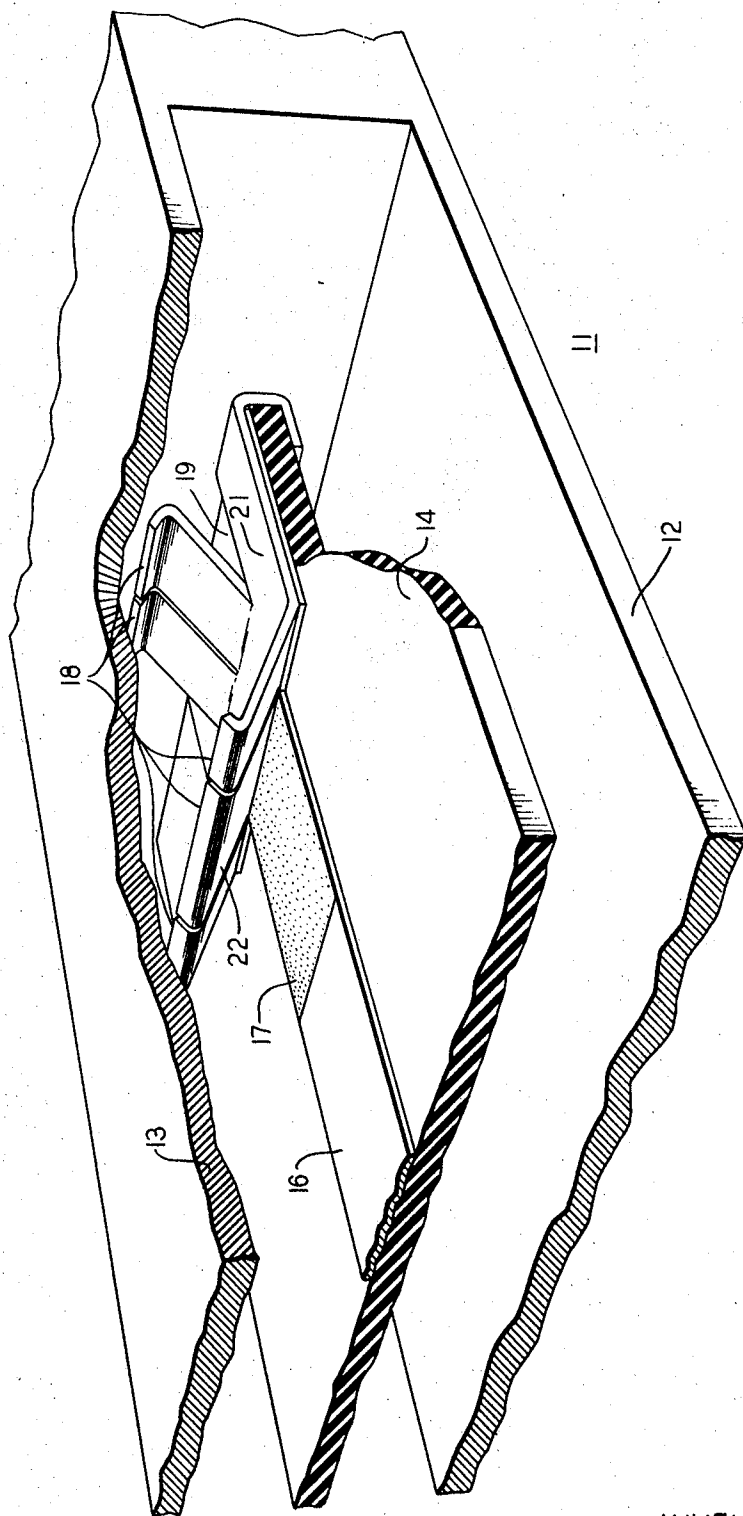
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ABSTRACT: A thin-film resistive termination is presented for impedance matching microwave strip lines over a broad frequency band with a leaf spring connecting the resistor to the upper ground plane of the termination. The leaf spring is sloped along the length of the resistive film to produce a distributed capacitance which compensates for the series inductance of the resistive film.



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STRIPLINE THIN-FILM RESISTIVE TERMINATION WHEREIN CAPACITIVE REACTANCE CANCELS OUT UNDESIRED SERIES INDUCTANCE OF RESISTIVE FILM

BACKGROUND OF THE INVENTION

This invention relates to microwave transmission lines and, more particularly, to terminations for microwave transmission strip lines.

The maximum power transfer theorem states that maximum efficiency of transmission lines is realized by impedance matching with a real impedance equal to the characteristic impedance of the line. Under this impedance matching condition, in an ideal transmission line termination, substantially all the transmitted power is absorbed by the termination and no reflection occurs. Thus, a voltage-standing wave cannot be produced by the interaction of transmitted and reflected wave energy.

Although the requirements of a microwave termination are basic, at microwave frequencies parasitic, distributed, and fringing effects give rise to reactive impedances that become significant and make a purely resistive termination difficult to achieve. The art of terminating coaxial microwave transmission lines has successfully overcome these obstacles, and a wide variety of coaxial line terminations are available to those who work in the art. Terminations for strip lines, however, are difficult to fabricate and generally do not have the precision of coaxial line terminations. Microwave stripline circuits have become popular due to the following advantages: economy and ease of manufacture, light weight, design flexibility and miniaturization. In order to utilize these advantages to the fullest extent, it would be highly desirable to have a stripline termination that does not offset the advantages of stripline techniques.

Two alternatives for terminating microwave strip lines are currently available to those working in the art. Either coaxial line microwave terminations can be used in conjunction with adapters for the transition from strip line to coaxial line, or terminations can be specifically designed for the stripline arrangement. Stripline terminations of the present state of the art require precision machinery to fabricate a device adaptable to the stripline arrangement. These terminations generally employ the technique of extending an upper and lower portion of the ground plane with a tapered cavity machined in a solid piece of conductive material. The tapered or wedge-shaped cavity provides an electrical connection to the dissipating element of the termination at the apex of the cavity. The cavity is shaped to provide a smooth transition from the stripline dimensions to the dissipating element of the termination. The characteristic impedance of a transmission line is dependent upon physical dimensions of the line, hence the gradual or tapered changes in dimensions allow the introduction of the dissipating element without producing an impedance discontinuity which would destroy the properties of the termination. Such approaches are both inconvenient and costly, and destroy the aforementioned advantages of microwave stripline circuits.

SUMMARY OF THE INVENTION

The present invention overcomes the disadvantages of the aforementioned alternatives and preserves the inherent advantages gained by employing strip lines. Specifically, both alternatives are adaptations that alter the stripline dimensions in distinction to the present invention which utilizes the stripline geometry as it stands. In an illustrative embodiment of the invention, a resistive thin-film layer is placed in electrical contact with the center conductor of the strip line. Both the resistive layer and the center conductor are supported by a dielectric supporting member. Similarly, a conductive pad is supported by the dielectric member in electrical contact with the opposite end of the resistive layer. A leaf spring, designed to slide over the end of the dielectric member, establishes an electrical return path for the termination circuit between the conductive pad and the upper ground plane portion of the ex-

isting strip line. Therefore, the present invention becomes an integral part of the established microwave transmission strip line.

The leaf spring extends from the conductive pad over the resistive layer to a point on the upper ground plane portion longitudinally removed from the conductive pad in the direction of the center conductor. The tapered spacing between the resistive layer and the leaf spring provides a distributed capacitance gradient sufficient to cancel out the undesirable series inductance of the resistive layer. At microwave frequencies, the series inductance becomes a significant factor that produces a reactive impedance which destroys the purely resistive terminating quality of the thin-film resistive layer. Thus, the present invention produces a substantially purely resistive termination.

BRIEF DESCRIPTION OF THE DRAWING

The sole FIGURE is a perspective view of the termination of the present invention.

DETAILED DESCRIPTION

The FIGURE shows the stripline termination 11 comprising an upper ground plane 13, a lower ground plane 12, a dielectric sheet 14, a center conductor 16, a resistive layer 17, a conductive pad 19 and a leaf spring 21. In the FIGURE, the resistive layer 17 of the termination 11 is mounted on the dielectric sheet 14 spaced midway between upper ground plane 13 and lower ground plane 12, which form the symmetrical type TEM transmission line which is often referred to as a strip line. For simplicity of illustration, no supporting structure is shown in the FIGURE for the dielectric sheet 14. The conductive ground plane structure, which comprises the upper ground plane 13 and the lower ground plane 12, extends laterally from the center conductor 16 of the strip line a sufficient distance to act as a substantial shield for the center conductor 16 and eliminates any possibility of radiation loss from it. It should be understood, however, that the invention may be applied to lines of the nonsymmetrical type, sometimes referred to as Microstrip, in which a single ground plane only is employed.

In the fabrication of the metallization pattern on the sheet of dielectric, thin-film techniques can be conveniently employed. The sheet 14 of dielectric material would usually be a ceramic material such as alumina. Other ceramics, however, such as beryllia, offer different features such as high thermal conductivity which could improve the power dissipation of the termination. The deposition of the metallizing on the dielectric sheet 14 could be done by either evaporation or sputtering, or a combination of both, depending on the particular combination of metals used. Once electrical conductivity is established over the working surface of the dielectric sheet 14, electrochemical plating can be used to provide a further combination of metals of thicker layers for greater conductivity. A convenient approach to the fabrication process is to deposit and plate the metals selected over the entire working surface and then to etch metals selectively through photographically-produced masks. This approach offers the greatest design flexibility and ease of manufacture.

To be more specific, the following metallization scheme could be employed: sputter tantalum nitride on one side of the dielectric sheet 14, evaporate titanium on the Ta₂N layer, evaporate gold on the titanium, plate copper and then gold on the entire working surface of the dielectric sheet 14. Selectively etch metals in successive steps using a different photographic mask for each respective geometric area during each step to define respective geometric areas of center conductor 16, conductive pad 19 and resistive film 17. When the tantalum nitride film is deposited, a sufficient amount of material is used to obtain a resistance value of the resistive film area lower than the characteristic impedance of the strip line. Finally, the tantalum nitride layer, while being monitored, can be anodized to a resistive value equal to the characteristic im-

pedance of the strip line. The tantalum nitride offers a low temperature coefficient of resistance and good long term stability, which are desirable properties for microwave terminations.

The leaf spring 21 can be formed by etching a pattern corresponding to the periphery of the leaf spring in a sheet of conductive, resilient material such as beryllium copper. The proper tooling is applied to the pattern to obtain the shape of the leaf spring 21 illustrated in the drawing. The leaf spring 21 is gold plated as an allowance for the predominant skin effects at microwave frequencies while increasing the performance and the reliability of the termination.

By observing the FIGURE, one can see that the center leaf 22 of the leaf spring 21 extends from the conductive pad 19 over the resistive layer 17 to a point on the upper ground plane 13 longitudinally removed from the conductive pad in the direction of the center conductor 16. In addition to completing the electrical circuit, the leaf spring provides a distributed capacitance gradient sufficient to cancel out the undesirable effects of the distributed series inductance of the resistive film.

Ideally, one would like to make the length of the resistive layer as short as possible in order to minimize the series inductance which is proportional to the length. Other considerations, however, make this single consideration undesirable. For example, the width of the resistive layer 17 should be equal to the width of the center conductor 16 so that an impedance discontinuity is not introduced into the termination. Furthermore, the available sheet resistivity of the film requires a finite length to yield a resistance equal to the nominal characteristic impedance of the strip line. From the standpoint of power dissipation, a sufficient area is required to dissipate the electromagnetic wave energy.

The most effective way to eliminate the distributed series inductance of the film is by a distributed capacitance acting directly on the inductance reactance. The capacitance and inductance must be at the same location in the strip line to broad-band compensate the termination effectively. Any displacement between the two reactances becomes more detrimental as the frequency increases and the wavelength becomes shorter. If there is a displacement between the two reactances frequency-dependent impedance transformation will occur, making broad-band compensation impossible.

Taking electrical field distribution into consideration, the center leaf 22 of the leaf spring 21 provides a lateral overlap which extends 0.012 inch past both side edges of the resistive layer 17. The leaf spring 21 is furcated into five contacting branches to increase reliability by having a plurality of contact

points. Furthermore, each of the furcated contacting branches has a 0.020 inch lip 18 that insures multiple points of intimate electrical contact with the upper ground plane 13. The aforementioned lip 18 reduces the space between the resistive layer 17 and the center leaf 22 of the spring. The latter has the effect of increasing the distributed capacitance sufficiently within the peripheral bounds of the resistive layer 17 to eliminate substantially the effects of the series inductive reactance of the resistive layer.

In all cases it is to be understood that the above-described arrangement is merely illustrative of a small number of the many possible applications of the principles of the invention. Numerous and varied other arrangements in accordance with these principles may readily be devised by those skilled in the art without departing from the spirit and scope of the invention.

What I claim is:

1. A microwave stripline termination comprising,
 - a pair of spaced ground plane conductors which are substantially parallel,
 - an elongated center conductor mounted on a member of dielectric material and positioned substantially midway between said ground plane conductors,
 - a resistive layer mounted on said dielectric member and having one end conductively connected to said center conductor and the other end conductively connected to a conductive pad, and

means for producing a distributed capacitance gradient along said resistive layer comprising a resilient conductive member extending from said pad in the direction of said center conductor.

2. The termination of claim 1, wherein the resistance of said resistive layer is substantially equal to the characteristic impedance of the strip transmission line in which said termination is contained.

3. The termination of claim 1, wherein the capacitive reactance of said distributed capacitance gradient substantially equals the series inductive reactance of said resistive layer to produce a substantially purely resistive termination.

4. The termination of claim 1, wherein furcated contacting branches of said resilient conductor member extend to a plurality of contacting points on one of said ground plane conductors in the longitudinal region of said conductive pad and longitudinally removed from said conductive pad in the direction of said center conductor, each of said contacting branches having a contacting lip in contact with said one ground plane to establish intimate electrical contact between said one ground plane conductor and said contacting lip.