

Dec. 9, 1969

N. R. DIETRICH

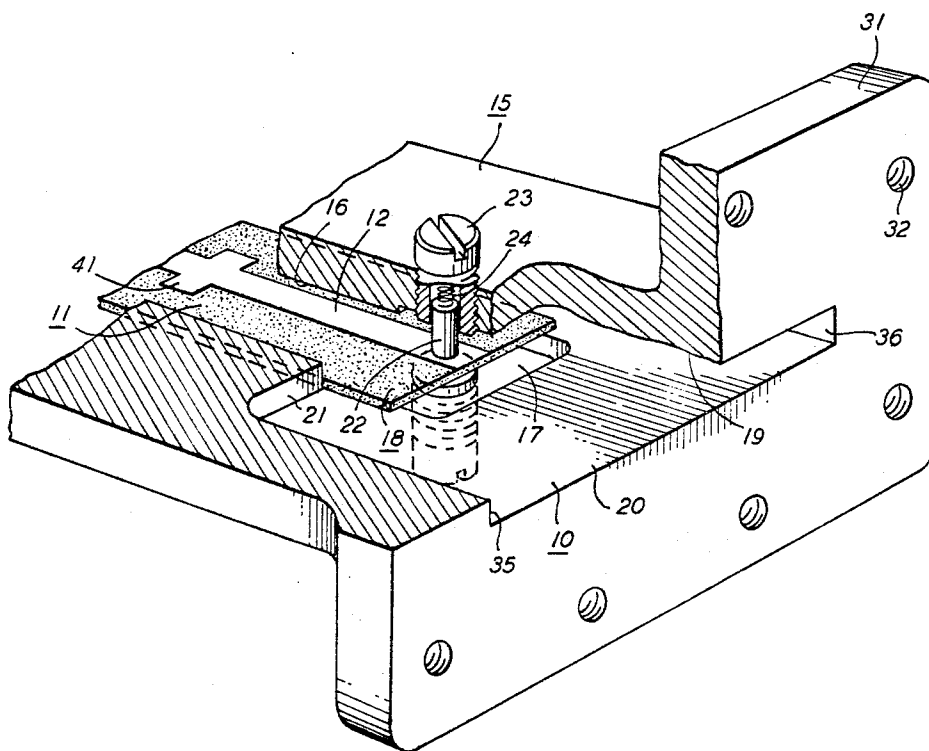
3,483,489

END LAUNCH STRIPLINE-WAVEGUIDE TRANSDUCER

Filed Jan. 31, 1968

2 Sheets-Sheet 1

FIG. 1



INVENTOR
N. R. DIETRICH
BY *Ray M. Porter Jr.*
ATTORNEY

Dec. 9, 1969

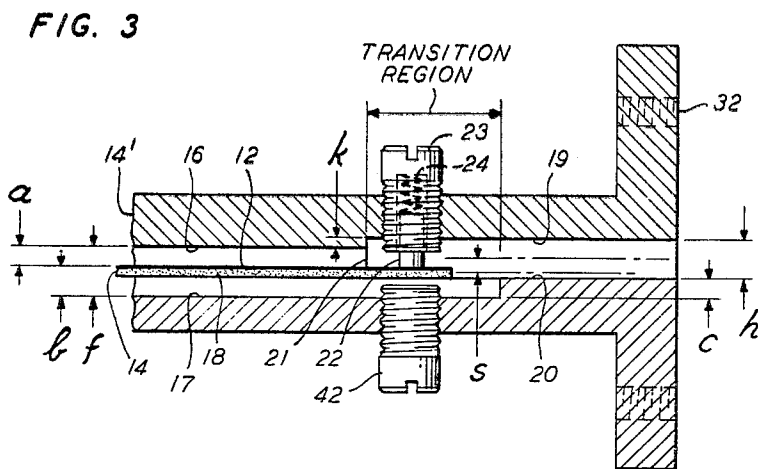
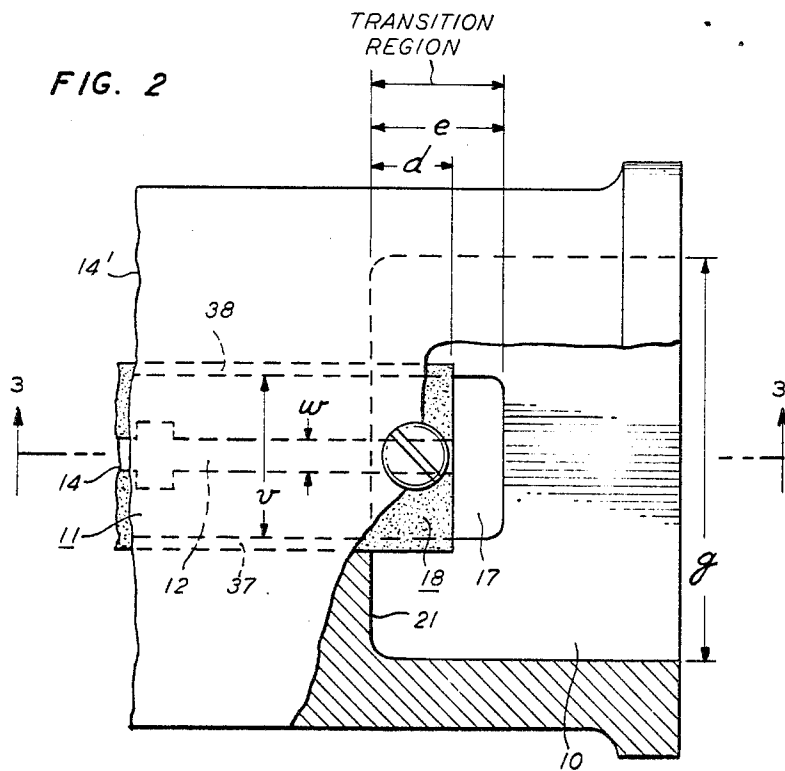
N. R. DIETRICH

3,483,489

END LAUNCH STRIPLINE-WAVEGUIDE TRANSDUCER

Filed Jan. 31, 1968

2 Sheets-Sheet 2



1

3,483,489

END LAUNCH STRIPLINE-WAVEGUIDE TRANSDUCER

Norman R. Dietrich, Allentown, Pa., assignor to Bell Telephone Laboratories, Incorporated, Murray Hill and Berkeley Heights, N.J., a corporation of New York
Filed Jan. 31, 1968, Ser. No. 701,913
Int. Cl. H01p 1/16

U.S. Cl. 333-21

6 Claims

ABSTRACT OF THE DISCLOSURE

A stripline is connected end-to-end with a hollow waveguide. The stripline center conductor is inserted into the waveguide and is shorted to the waveguide wall by a screw mechanism. One of the stripline ground planes terminates at the waveguide end wall, and the other is inserted into the waveguide for a selected distance. Coupling is achieved without undesirable radiation and a good impedance match is provided.

BACKGROUND OF THE INVENTION

This invention relates to radio frequency transducers and more particularly to a transducer for end launch coupling between a waveguide of the rectangular hollow conductor type and one of the parallel strip, multiple conductor type such as the stripline.

Mixed microwave circuits, in which part of the circuit is in the form of conductively bounded waveguides and part is in the form of parallel strip conductors, are becoming increasingly popular with the development of microwave integrated circuit techniques. In such circuits, it is generally necessary to transfer energy one or more times between transmission lines of these different types. Printed circuit and thin film technology have made possible microwave integrated circuits in which many microwave functions are integrated into a single package using stripline as the sole transmission media throughout the package. However, some components are not yet susceptible to direct stripline connection and must at present be connected to hollow waveguides. A system which includes such components must therefore provide interconnections between stripline and hollow waveguide. In many cases it is convenient to join the waveguide and stripline in an end-to-end connection, especially where the system includes components which tend to be interconnected end-to-end. In these situations, such an end-to-end interconnection is a mechanical expedient which avoids the structural difficulties of a perpendicular mating.

Structural interconnection is relatively simple to achieve, but electrical coupling presents difficulties. Typically, transition must be provided between the principal stripline TEM mode and the dominant TE₁₀ mode in the rectangular waveguide. As is well known in the art, such a transition may be accomplished either by means of a probe inserted through the broad wall of the waveguide parallel to the electric field of the guide or by means of a loop, the plane of which is normal to the magnetic field, shorted to a wall of the guide. The former method utilizes electric field coupling and is referred to as a top launch transition. The latter method is referred to as an end launch transition and employs magnetic field coupling. A top launch transition necessitates the perpendicular orientation of the TEM and TE₁₀ transmission lines and is hence not as convenient for use with microwave integrated circuitry as is the end-to-end coupling.

2

Though the stripline and rectangular waveguide possess structural similarities, they are physically distinct and hence possess different characteristic impedances. A means is therefore needed to provide a good impedance match for the end launch TEM-TE₁₀ transition. Transducers now being used in the art for this purpose employ well-known impedance matching techniques such as dielectric matching, transition through an intermediary coaxial section, or tapering members in the transition region. Examples of the latter type may be found, for example, in United States Patents 2,825,876, granted Mar. 4, 1958 to D. J. LeVine et al. and 2,979,676, granted Apr. 11, 1961 to L. J. Rueger.

It is an object of the present invention to provide a simple direct end launch transition from stripline to rectangular waveguide which provides a good impedance match.

SUMMARY OF THE INVENTION

In accordance with the invention, a portion of the stripline is inserted longitudinally into a hollow waveguide in an end-to-end relationship. Structural elements of both the stripline and the waveguide are coextensive in a transition region and within this region the field patterns of the stripline TEM mode and the waveguide TE₁₀ mode are coextensively supported. The TEM field pattern is supported in the transition region by the center conductor and one of the two stripline ground planes which extend through an opening in an end wall of the guide into the transition region. The extended ground plane is an indented surface in a first broad wall of the waveguide. In the transition region the TE₁₀ field pattern is supported by the waveguide channel which is identical to the channel outside the region except for the aforementioned indentation.

Coupling takes place in the transition region where the field patterns of both transmission media are coextensive. The stripline conductor is shorted to a second broad wall of the waveguide by means of a screw mechanism in a manner which creates interaction of the field patterns of both modes. An impedance match is therefore made possible since the field patterns are coextensive within the transition region.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a cut-away perspective view of an end launch waveguide-stripline transducer in accordance with the present invention;

FIG. 2 is a cut-away top view of an end launch waveguide-stripline transducer in accordance with the present invention; and

FIG. 3 is a cross-sectional view taken through FIG. 2, as indicated, to show in elevation the transition region in accordance with the present invention.

DETAILED DESCRIPTION

Referring more particularly to the drawing, an illustrative embodiment of an end launch transition between a rectangular conductively bounded waveguide and a parallel conductor stripline is shown. The transition between the TEM mode in stripline 11 and the TE₁₀ mode in waveguide 10 occurs in the transition region.

The channel of waveguide 10 is defined by upper wall 19 and parallel lower wall 20, parallel narrow side walls 35 and 36 and end wall 21 cut in body 15. Waveguide 10 is connected to additional waveguide lengths, not shown, by any of a variety of means. In the particular embodiment shown, an additional length may be fixed to waveguide 10 by means of bolts passing through holes 32 in

flange 31 and through corresponding holes in a corresponding flange of the length not shown. Stripline 11 is shown truncated along lines 14 and 14' and having thin center strip conductor 12 disposed between a pair of ground planes 16 and 17. Strip conductor 12 is a fixed distance a from ground plane 16 and a fixed distance b from ground plane 17. Strip conductor 12 is typically supported by being formed of a conductive material plated or printed upon a supporting substrate 18 of high dielectric material. It should be understood, however, that the invention may be applied to striplines having self-supporting center conductors or to lines in which ground planes are bounded or plated surfaces in the familiar sandwich construction.

In accordance with the invention structural members of both stripline 11 and waveguide 10 are coextensive within a transition region. A portion of stripline 11 is inserted into waveguide 10 through an opening in end wall 21. As can be clearly seen, center strip conductor 12 and its supporting substrate 18 extend into waveguide 10 a distance d beyond end wall 21. Conducting ground plane 17, which in the embodiment shown has a width v substantially less than the width g of waveguide 10, extends into waveguide 10 a distance e beyond end wall 21. Ground plane 16 terminates at end wall 21.

In the transition region conductor strip 12 is shorted to upper wall 19 of waveguide 10 by means of a conducting contact pin 22 riding in a cylindrical channel in screw 23 under pressure of spring 24. The pressure applied by pin 22 to strip conductor 12 is adjustable by advancing and retracting screw 23 by means of suitable threading on the exterior of screw 23 and corresponding threading in body 15 passing through wall 19. The spring constant of spring 24 and adjustment of screw 23 are chosen to maintain electrical contact between the waveguide wall and conductor 12 without breaking strip conductor 12 or substrate 18.

The short thus formed by pin 22 couples TEM mode currents into a magnetic field surrounding the shorting mechanism which is in the plane of the magnetic field of the TE_{10} mode of waveguide 10. In order to make the field patterns of the TEM_{10} and TEM modes coextensive in a transition region and afford a smooth transfer of energy between the modes, the waveguide channel must extend throughout the transition region to support the TE_{10} mode, and ground plane 17 and stripline conductor 12 must be arranged to provide TEM propagation throughout the region. Plane 17 and conductor 12 must extend beyond the point of the short in order to avoid undesirable effects upon the TEM mode field in the range of the short. Ground plane 16 is terminated at end wall 21 to prevent a short circuit between conductor 12 and plane 16 which would affect the TEM mode field. Wall 19 extends beyond the shorting screw in order to avoid undesirable effects upon the TE_{10} mode field in the range of the short.

It is believed that the best impedance match will be obtained if center strip conductor 12 lies in the plane of lower wall 20. Good operation is obtained however if the separation between the plane of conductor 12 and the plane of wall 20 is small compared with the height h of waveguide 10, and a small separation simplifies mechanical support of conductor 12 in the transition region. Conductor 12 is shown lying in a plane above the plane of wall 20 by the thickness of the supporting substrate 18. Substrate 18 rests on wall 20 within the transition region and on channels 37 and 38 which are machined flush with surface 20 on the stripline side of the transition region. Since it is advisable that conductor 12 lie as close to the plane of wall 20 as possible, variation in the separation f between ground planes 16 and 17 of stripline 11 will automatically alter offset c , and variation in the height h of waveguide 10 will be compensated for in offset k . Thus, for any sized stripline and any sized waveguide the centerlines of the stripline and waveguide,

which lie respectively in the plane midway between the ground planes of the stripline and midway between the broad walls of the waveguide, will be maintained. Even if height h and separation f are equal an offset will still exist.

It has been found that fine adjustment of the impedance match can be obtained by placing a lumped reactance such as 41 on the stripline center conductor at a distinct distance from the transition region. Use of such lumped reactances is well known in the art. Additional adjustment may be obtained by capacitively coupling conductor 12 to extended ground plane 17 within the transition region. One of many possible means of accomplishing this is shown. Screw 42 with appropriate threading is inserted through body 15 coaxially with screw 23. Screw 42 passes through ground plane 17 and effectively raises or lowers a section of ground plane 17 to vary the coupling between ground plane 17 and center conductor 12.

As a specific example, an end launch transition which provides a good impedance match has been designed for coupling waveguide 10 and stripline 11 where stripline 11 has an infinitesimally thick center strip conductor 12 of width $w=.114$ inch plated on substrate 18 having a thickness of .024 inch and ground planes 16 and 17 having widths $v=.600$ inch separated from strip conductor 12 by distances $a=.050$ inch and $b=.075$ inch respectively. The height h between broad walls 19 and 20 of hollow waveguide 10 is .100 inch and the width of broad walls 19 and 20 is $g=1.590$ inches. Ground plane 17 is extended into waveguide 10 a distance $e=.465$ inch at an offset from the flush with wall 20 of $c=.050$ inch. Substrate 18 and strip 12 extend into the transition region a distance of $d=.300$ inch where strip 12 is shorted to wall 19 by a screw having its axis .187 inch from end wall 21. The resultant offset of centerlines is $s=.038$ inch.

In all cases, it is to be understood that the above-described arrangement is merely illustrative of one 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.

I claim:

1. An electromagnetic wave transducer comprising a hollow conductively bounded rectangular waveguide, a parallel conductor line having a strip center conductor disposed in parallel spaced relationship to at least one conductive ground plane, a portion of said waveguide being coextensive with a portion of said one conductive ground plane and with a portion of said strip center conductor in a transition region, the broad walls of said waveguide in said region being parallel to and offset from said one ground plane such that said broad walls lie in planes different from the plane determined by said one ground plane, and means for shorting said strip conductor to a first of said broad walls within said region.

2. A transducer as in claim 1 wherein the plane of said center strip conductor is separated from the plane of a second of said broad walls of said waveguide by a distance small in comparison to the separation between said first and second broad walls of said waveguide.

3. A transducer as in claim 1 wherein said strip conductor is mounted on a first surface of a supporting substrate which is positioned such that a second surface of said substrate parallel to said first surface lies in the plane of a second of said broad walls of said waveguide.

4. A transducer as in claim 1 wherein said one conductive ground plane is substantially narrower than said waveguide and extends into said transition region to form an indented surface in a second of said broad walls of said waveguide.

5. A transducer as claimed in claim 1 further comprising means for capacitively coupling said strip center conductor to said one ground plane within said region.

6. A combination in which a hollow conductively

5

bounded waveguide is coupled for frequencies of electro-
magnetic wave energy within a given band to a second
waveguide of the type having a strip conductor disposed
in parallel spaced relationship to at least one conductive
ground plane, said second waveguide being disposed in
a longitudinal end-to-end relationship to said hollow
waveguide with a portion thereof extending into said
hollow waveguide characterized in that the centerlines
of said hollow and said second waveguide are offset from
one another and means are provided for conductively
connecting said strip conductor to a wall of said hollow
waveguide and means are provided for extending said
conducting ground plane a selected distance into said
hollow waveguide.

6

References Cited

UNITED STATES PATENTS

2,501,335	3/1950	Hunter	-----	333—33
3,023,382	2/1962	Borghetti	-----	333—34
3,146,410	8/1964	Butler	-----	333—21
3,265,995	8/1966	Hamasaki	-----	333—21
3,293,573	12/1966	Krank et al.	-----	333—21

HERMAN K. SAALBACH, Primary Examiner
M. NUSSBAUM, Assistant Examiner

U.S. Cl. X.R.

333—33, 84