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Tsironis

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(54) **LOW-LOSS MICROWAVE DEVICE TEST FIXTURE WITH ADJUSTABLE BLOCKS**

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(51) **Int. Cl.**^{7} **H03H 7/38**
(52) **U.S. Cl.** **333/33**; 333/246
(58) **Field of Search** 333/33, 246, 260; 324/765–769

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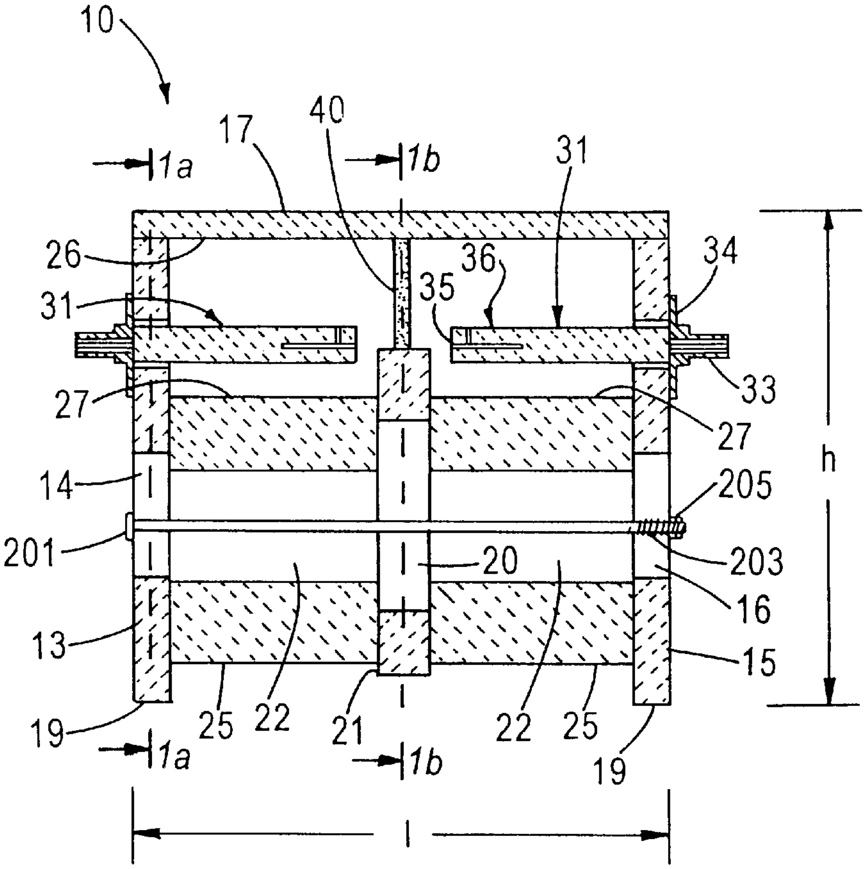
(57) **ABSTRACT**

The present invention relates to a low-loss microwave device test fixture which presents as little losses as possible along the signal path and which can permit impedance transformations. The test fixture includes a frame having two opposite extremities, a top, a bottom, a height and a width. The device is further provided with a device supporting column located between the two extremities, having a top surface lying below the top of the frame adapted to receive the device. Two adjustable blocks are further provided, each located between the device supporting column and an opposite extremity, each of the blocks being vertically adjustable. Between the adjustable blocks and the top of the device are two brackets, each for receiving a flange of a device, each of the brackets being secured to an opposite extremity of the frame. The device can be secured to the column and the column and the blocks can be vertically adjusted. The vertical adjustment permits the impedance transformation, and air is used as a dielectric to minimise the losses along the signal path.

8 Claims, 6 Drawing Sheets



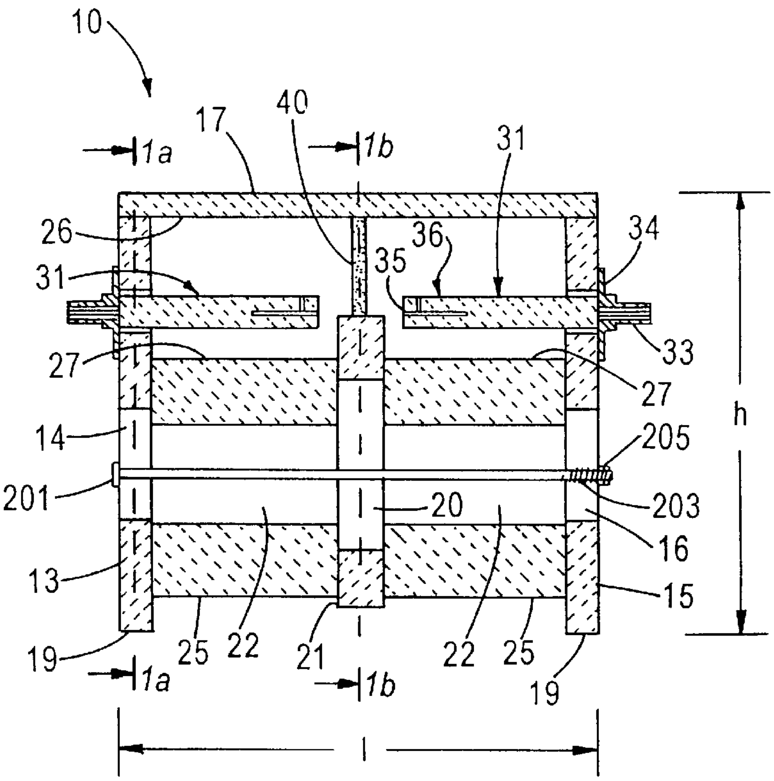


FIG. 1

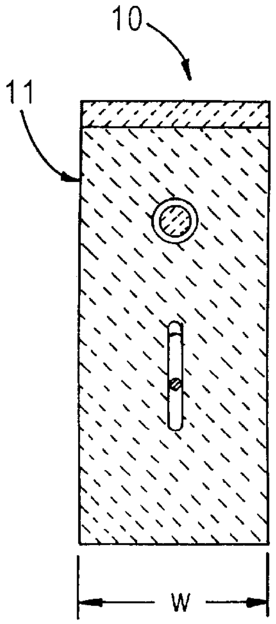


FIG. 1a

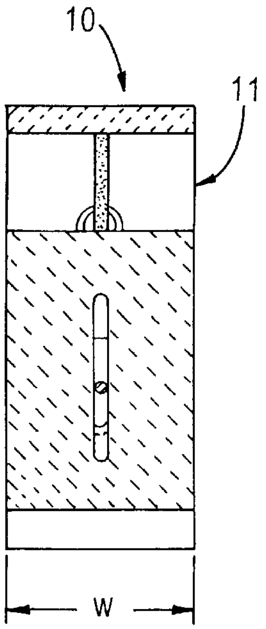


FIG. 1b

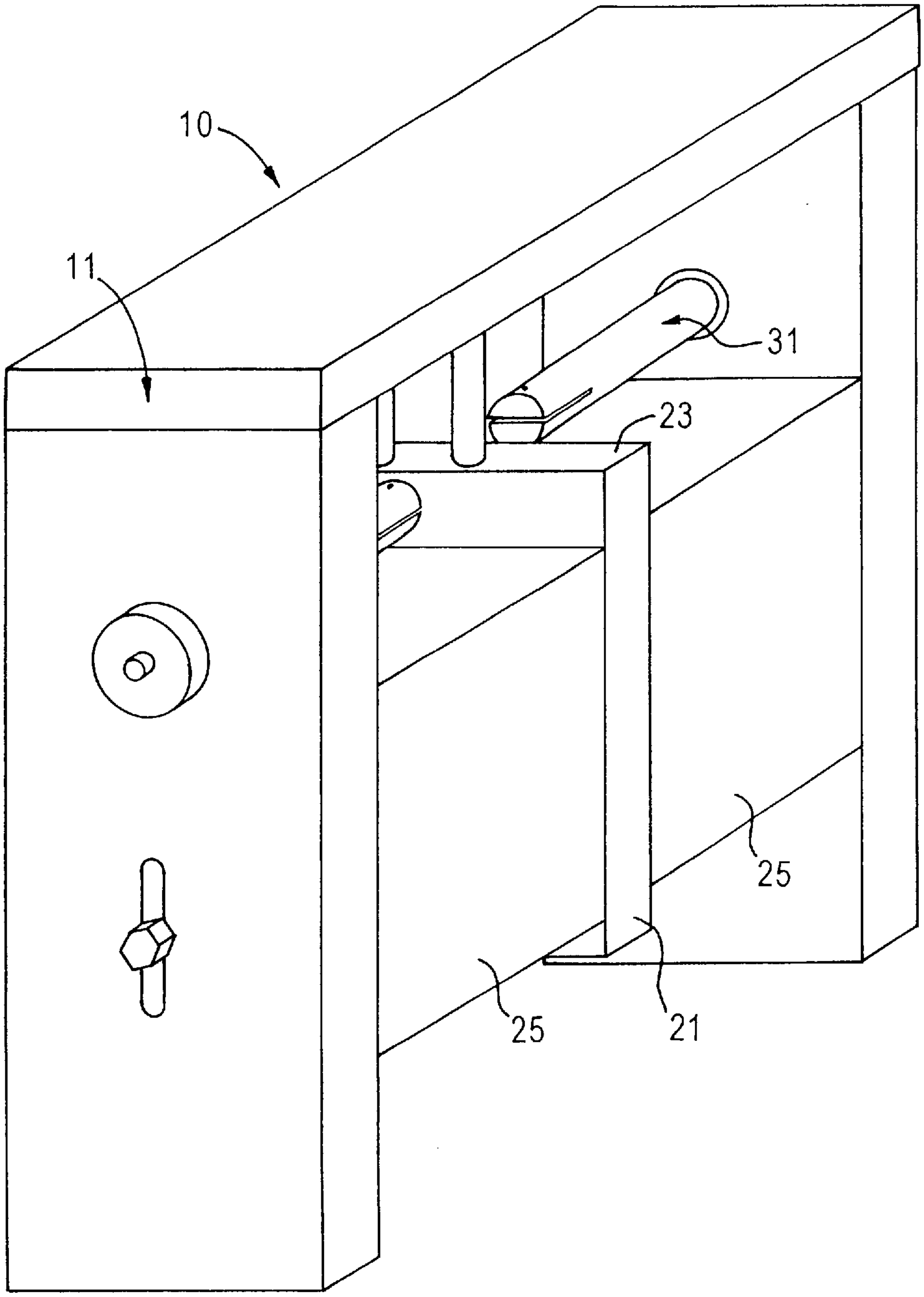


FIG. 2

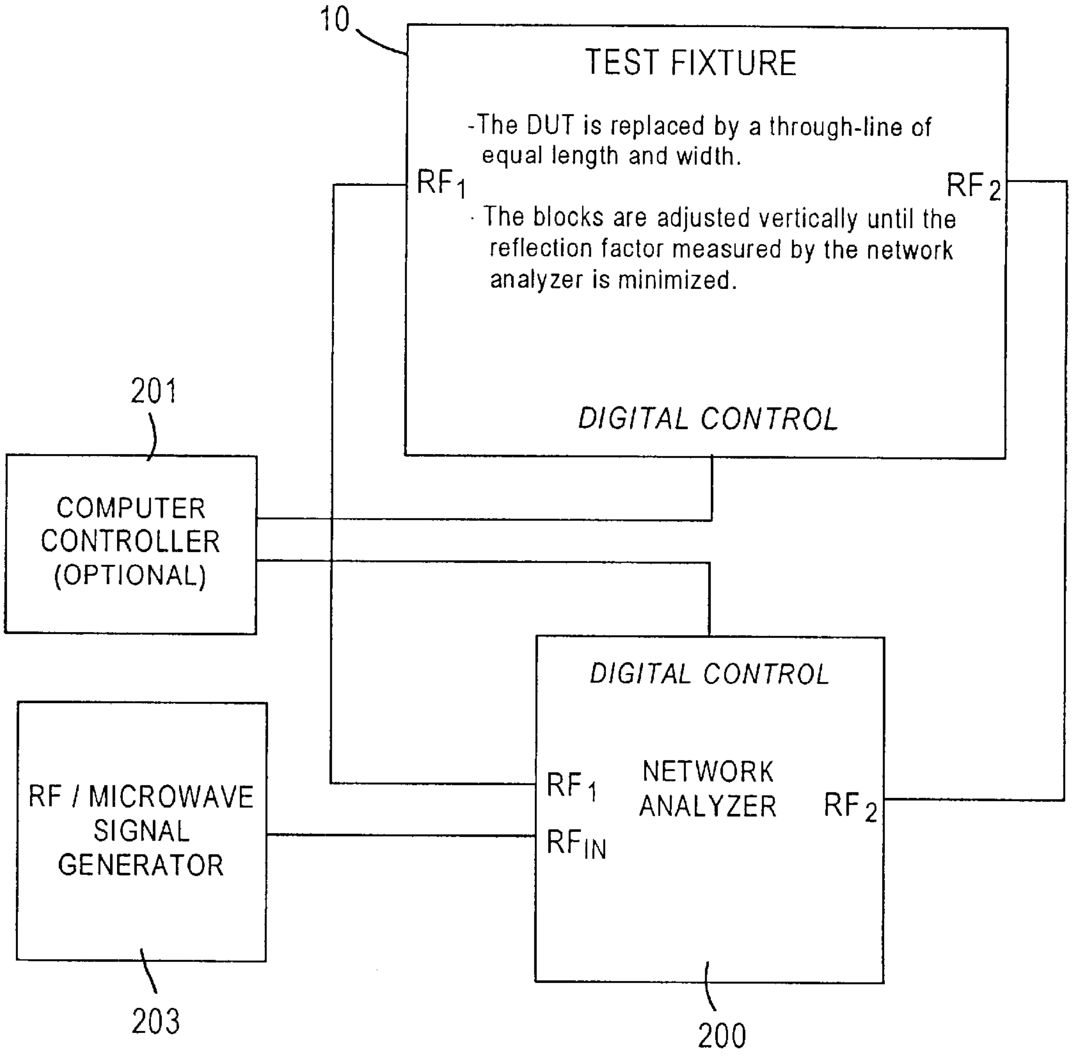

10
TEST FIXTURE
-The DUT is replaced by a through-line of equal length and width.
· The blocks are adjusted vertically until the reflection factor measured by the network analyzer is minimized.
RF1
RF2
DIGITAL CONTROL
201
COMPUTER CONTROLLER (OPTIONAL)
DIGITAL CONTROL
NETWORK ANALYZER
RF1
RFIN
RF2
RF / MICROWAVE SIGNAL GENERATOR
203
200

FIG. 3

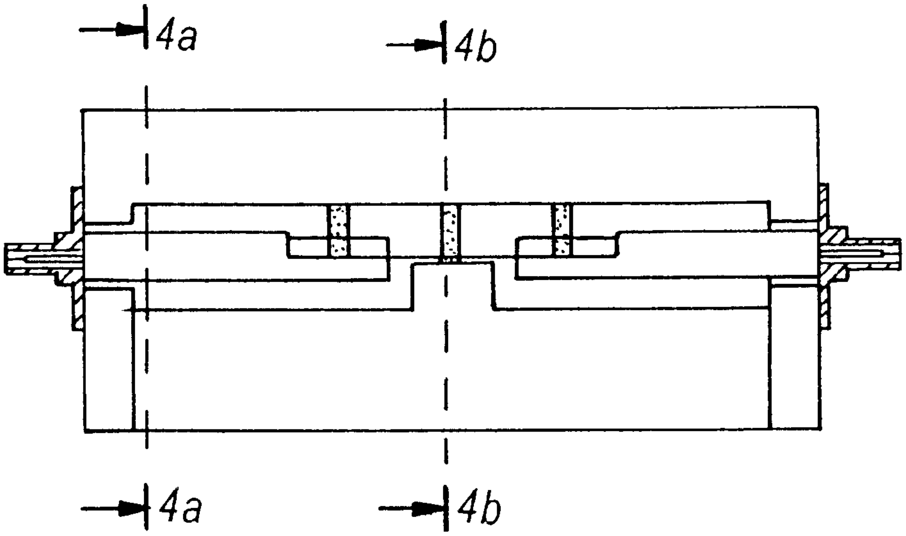


FIG. 4
(PRIOR ART)

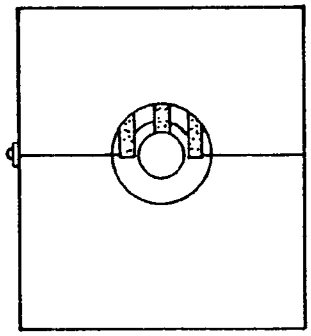


FIG. 4a
(PRIOR ART)

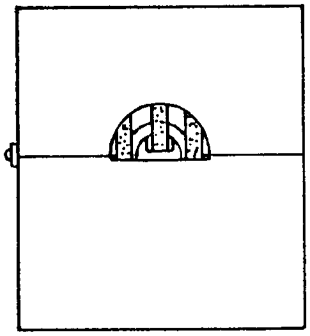


FIG. 4b
(PRIOR ART)

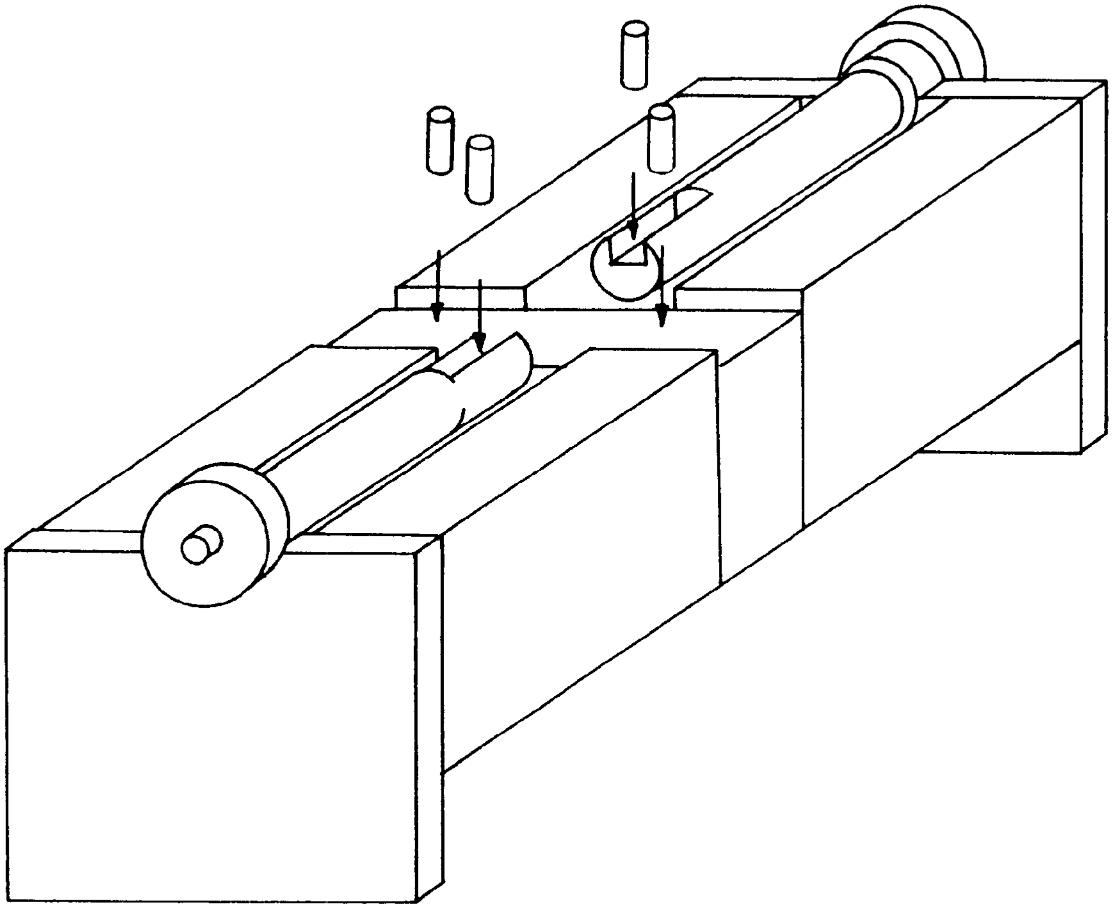


FIG. 5

(PRIOR ART)

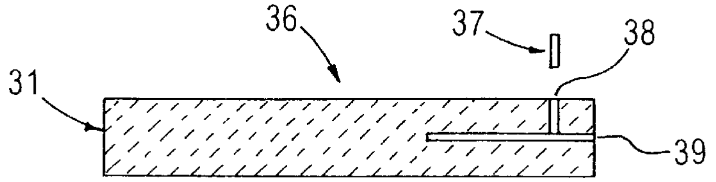


FIG. 6a

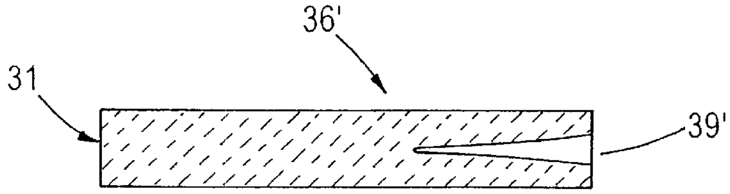


FIG. 6b

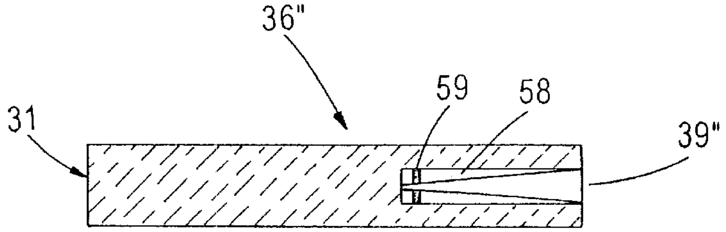


FIG. 6c

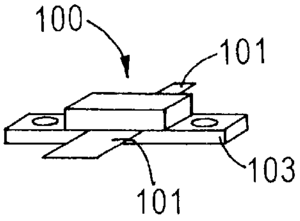


FIG. 7a

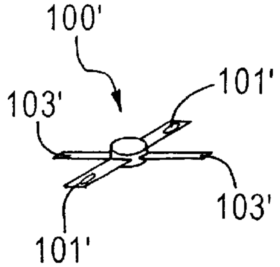


FIG. 7b

LOW-LOSS MICROWAVE DEVICE TEST FIXTURE WITH ADJUSTABLE BLOCKS

The present application claims priority to U.S. provisional application No. 60/186,202, filed Mar. 1, 2000.

FIELD OF THE INVENTION

The present invention relates to a low-loss microwave device test fixture.

DESCRIPTION OF THE PRIOR ART

Low-loss microwave device test fixtures are typically used in automatic and manual RF/microwave (200 MHz to 26.5 GHz) measurement and testing of microstrip and coplanar devices (hereinafter "DUT") operating in linear or non-linear mode.

These test fixtures are used within measurement set-ups to provide a mechanical base on which to physically install a RF/microwave device to be measured, such as transistor, diode, MMIC, etc. and provide a means to create a signal path from the inputs and the outputs of the devices to measurement equipment. The use of a test fixture is dictated by the fact that the packages in which devices are delivered are meant for PC-board mounting applications and cannot be hooked directly on test equipment connectors.

Generally, the packages in which the devices **100**, **100'** are delivered comprise a main body **103**, **103'**, usually meant to be secured to a circuit ground, and two or more flanges **101**, **101'**, identified as inputs, outputs and sometimes grounds as shown in FIGS. **7***a* and **7***b*. All these elements are internally connected to different sections of the actual microwave microchip die. In all existing fixtures, devices are positioned and retained in place through a variety of methods (soldering, clamping, spring loading, etc.), and can be adjusted to different packages by replacing, adding or removing mechanical sections and PC-boards optimized for each specific application.

In almost all prior art fixtures, the transitions between the fixture connectors and the device package flanges are realised by using printed copper patterns over some dielectric substrate. The reason for this is that such an arrangement permits easy adaptation to different packages just by replacing a PC-board, as well as the possibility of achieving impedance transformation, consequently allowing the characterization of very low impedance devices. Also, each transition can be easily designed for the specific package dimensional characteristics (flanges of different sizes, placed at various heights, etc.). In particular, this allows the characterisation of devices mounted within geometrically asymmetrical packages. Unfortunately, such an approach also has a major draw-back: all known dielectric materials used in substrates have high ohmic losses compared to air.

In the very case in which devices presenting extremely low impedances at one of their ports have to be tested using a Load Pull Test System, which varies the load or source impedance seen by the devices at their ports, the ohmic losses generated by the dielectric material cannot be ignored, effectively putting a limit to the lowest possible impedance that can be accurately generated by the load pull test system. In fact, non-resistive losses can always be extracted mathematically from the values measured (by a process known as "de-embedding"). However, it is of no importance to know exactly the effect of the ohmic losses in order to create the appropriate test conditions for the device; it is the fact that these ohmic losses limit the lowest available impedance presented to the device that matters. The most obvious approach to solve this problem is to design a fixture presenting as little losses as possible along the signal path. This is done by using dielectrics presenting as little ohmic losses as possible, the most appropriate dielectric for this purpose being empty space, closely followed by air.

However, up to now, air has been used as a dielectric in commercially available microwave device test fixtures only once. This test fixture is illustrated in FIGS. **4** and **5**, identified as "Prior Art". The test fixture has conductors having flange receiving portions. A section at the bottom of the device is custom-made for each separate DUT that is to be tested with the test fixture. Accordingly, whenever a new DUT is to be tested, the custom section must be replaced. Furthermore, this test fixture includes pressure columns (shown in solid in FIGS. **4**, **4***a* and **4***b*) in isolating material to maintain the DUT signal flanges in place, which by definition introduces losses; additionally, pressure columns are provided, again in isolating material, to hold the DUT ground flanges in place (see FIG. **5**).

This specific test fixture is inherently limited to small, low-power devices. Another limitation of this test fixture is that it does not provide any impedance transformation with the same custom section.

It is known from theory that achieving effective transitions using air as a dielectric and presenting good impedance transformation characteristics (more than 5:1) involves transitions of an extremely large size. Recent progress in measurement equipment and technologies however permits the direct measurement of extremely low impedances over very large frequency ranges. Consequently, investigating an approach using air has become far more interesting.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a microwave test fixture which presents as little losses as possible along the signal path, and which can permit impedance transformations. In accordance with the invention, this object is achieved with a test fixture which said device has at least two flanges lying on an axis and projecting on opposite directions from the device, and at least one ground flange, said test fixture comprising:

a frame having two opposite extremities, a top, a bottom, a height, and a width;

a device supporting column located between said opposite extremities, having a top surface lying below said top of said frame and adapted to receive said device, said column having a height less than said height of said frame;

two adjustable blocks, each located between the device supporting column and an opposite extremity, said blocks being vertically adjustable;

two brackets for receiving a flange from the device, the brackets lying above the column and the blocks, each bracket being secured to an opposite extremity of the frame;

means for securing said device to said column; and means for securing said column and said blocks at a given vertical position.

The advantages provided by the microwave test fixture according to the present invention are the following: the fixture uses air as the exclusive dielectric transmission media; the characteristic impedance may be varied by continuously changing the distance of the signal carrying conductor from the ground plane; and the fixture can inherently be securely attached to a wide variety of low and high power microwave transistor packages in order to make their testing possible.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention and its advantages will be more easily understood after reading the following non-restrictive description of preferred embodiments thereof, made with reference to the following drawings in which:

FIGS. **1**, **1***a* and **1***b* are, respectively, a front plan view, and schematic cross-sectional representations taken along lines **1***a* and **1***b*, of a microwave low-loss fixture for testing microwave devices according to a preferred embodiment of the invention;

FIG. **2** is a perspective view of the fixture of FIG. **1**;

FIG. **3** is a schematic representation of the set-up for calibrating the fixture of FIG. **1**;

FIGS. **4**, **4***a* and **4***b* are, respectively, a front plan view, and schematic cross-sectional representations taken along lines **4***a* and **4***b* of a test fixture according to the prior art; and

FIG. **5** is a perspective view of the prior art fixture with the top removed;

FIGS. **6***a*, **6***b* and **6***c* are schematic representations of various brackets which can be used with the device of the present invention; and

FIGS. **7***a* and **7***b* are schematic representations of typical DUTs used with the device of the present invention.

DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

The present invention concerns a novel microwave low-loss fixture **10** for testing microwave devices **100, 100'**. In this fixture **10**, transitions from connectors **36** to device flanges **101, 101'** do not rely on any dielectric substrate whatsoever. Two versions of the test fixture are described and form part of the invention:

1) A first preferred embodiment of the invention includes only a small amount of dielectric material within the commercially available connectors which are used to support the central conductor; and
2) A second preferred embodiment of the invention uses custom made connector assemblies without any dielectric support for the central conductors (known in the microwave engineering community as “beadless connectors”, in order to further reduce insertion loss).

Consequently, in both cases ohmic losses are extremely low, which is the objective of the invention and very desirable when low-impedance (less than 1 Ohm) devices need to be characterized, as, in these conditions, the influence of the test fixture losses in the measurement become critical for accuracy and limits the available reflection factor that can be synthesized at the DUT reference plane by means of a high reflection tuner.

Features from which this new fixture derives its benefits are the design of the device package flange holding brackets, and, more importantly, the specific approach used to guarantee a characteristic impedance within the signal path as close as possible to the desired one (50 Ohm, 75 Ohm, etc.).

The novel microwave device test fixture **10** according to the present invention is based on an innovative transition technique between coaxial and microstrip structures and has been optimized for each particular transistor package, in order to provide very low insertion loss and maximum return loss.

In the test fixture **10** of the present invention, the characteristic impedance is controlled all along the signal path by a vertically asymmetrical geometry which compensates for mismatches at the connector and flange level (see FIGS. **1** and **2**). The flanges themselves are positioned and held in place by a novel bracket (see FIGS. **1** and **2**) which not only provides excellent mechanical contact but also generates less ohmic losses than traditional methods. The basic principle of the brackets of the present invention is that the flanges are maintained in place by pressure means, either by a spring-loaded contact, a screw, or other similar means. This guarantees perfect and, also extremely important for microwave testing purposes, reproducible, contact for the signal path.

Adaptation to different sorts of packages is easily achieved by adding, removing, or replacing metallic sections below the body of the device.

It is important to mention that the low-loss microwave device test fixture **10** of the present invention, or test-jig, can easily be calibrated using a TRL (Through Reflect Line) technique. Unlike the traditional calibration techniques using precise open, short and 50 or 75 Ohms reference terminations, TRL does not require perfect or quasi-perfect references as long as the characteristic impedance of the delay-fine used in the calibration is known. Now, in this novel test fixture, the characteristic impedance can be very easily adjusted to the desired characteristic impedance (usually 50 Ohms) by adjusting the vertical distance between the through-line and the inserts, and minimizing the reflection loss as measured on a network analyzer (see FIG. **3**). Finally, as the dielectric constant of air (ϵ_0) is considerably lower than the one of any substrate, the width of the through-line has a much lower influence on the characteristic impedance measured between the input and the output of the test fixture. Consequently, the calibration set-up used for one transistor package can be used, achieving acceptable precision, with other similar packages.

Referring now to FIGS. **1** and **2**, the low-loss microwave device test fixture of the present invention is adapted to support devices **100, 100'** having at least two flanges **101, 101'** lying on an axis and projecting on opposite directions from the device, and at least one ground flange **103, 103'**. One of the flanges is denoted input, and the other flange is denoted output. FIGS. **7***a* and **7***b* show two such devices, although it should be understood that a variety of different devices can be used with the test fixture **10** of the present invention, as will be apparent from the following description.

The test fixture **10** of the present invention has a frame **11** having two opposite extremities **13, 15**, a top **17**, a bottom **19**, a height h, a width w, and a length l.

The fixture **10** further includes a device supporting column **21**, located between the opposite extremities **13, 15**, which has a top surface **23** lying below the bottom surface **26** of the frame **11** and adapted to receive the device **100**. The device supporting column **21** has a height which is less than the height h of the frame **11**.

The fixture **10** also includes two adjustable blocks **25**, preferably identical, but not necessarily so, each located between the device supporting column **21** and an opposite extremity **13** or **15**, as the case may be. The blocks **25** are vertically adjustable, so that the distance between the top surface **27** of each block **25** and the bottom surface **26** of the top **17** of the frame can be adjusted.

The fixture includes two conductors **31**, preferably identical, each of the conductors **31** having two opposite ends **33, 35**. End **33** is provided with a connector **34** to connect conductor **31** to an external device. End **35** is provided with a bracket **36** for receiving a flange of a device **100**. The conductors **31** lie on an axis between the bottom surface **26** of the top **17** and the top surface **27** of the blocks **25**.

The brackets **36** are preferably provided with a longitudinal slot **39**, having a predetermined length and width, that is adapted to receive a flange from a variety of different devices, the latter having different widths and different lengths. The brackets **36** are further provided with pressure means, for securely retaining the flange within the slot **39**. As better shown in FIGS. **6***a*, **6***b* and **6***c*, the pressure means can include a screw or a spring, or can simply be the shape of the slot **39**. More specifically, FIG. **6***a* shows a variation where the slot **39** is substantially rectangular. A flange of a device will be held in place within the slot by a screw **37** which will be screwed in hole **38**.

Alternatively, the slot **39**', illustrated in FIG. **6***b*, will taper inwardly and the flange of the DUT will be secured by the shape of the slot, which is sufficiently elastic, in combination with the flange, to be securely wedged in place.

Again, alternatively, the slot **39**", as shown in FIG. **6***c*, is rectangular, but larger than the one shown in FIG. **6***a*. The slot is provided with strips **58**, pivotally secured to bracket **32**" at the open area. The rearward portion of strip **58** is maintained away from the slot **39**" by resilient number **37**. When the DUT flange is inserted, it compresses number **37** to securely wedge the flange therein. It will be obvious that strip **58** must be conductive, but, element **57** does not tend to be.

Also, the embodiment shown in FIGS. **6***a*, **6***b* and **6***c* should not be interpreted as being limitative, and other ways of securely effecting a contact between connector **31** and the flange of the DUT is within the scope of the invention.

The purpose of the pressure means is to insure good contact between the conductor **31** and the flange of the device during the test.

As can be seen from FIGS. **1** and **2**, the conductors project towards the device supporting column **21**, and have a length less than half the length l of the fixture **10**.

In order to impart stability during the test, and to insure a good ground contact, means **40**, usually in the form of pressure columns, are adapted to press against the at least one ground flange of the device **100**, so as maintain the device **100** on the top surface **23** of the column **21**. These pressure columns can be in an insulating material, or in a conducting material.

Since the blocks **25** are vertically adjustable, means must be provided to maintain them is a predetermined vertical position. In a preferred embodiment of the invention, each block **25**, each opposite side **13**, **15** and the device supporting column **21** are provided with a vertical slot **22**, **14**, **16** and **20**, respectively. The means thus include a bolt **201** passing through each of the slots **22**,**14**, **16** and **20**, at having at least one threaded end **203** and a nut **205**. Once the blocks **25** and the column **21** have been placed in the desired vertical position, the nut **205** is tightened and the assembly thus remains secured. It should however be understood that other means to maintain the components in their desired vertical orientation are well within the scope of the present invention, and that the important aspect of the invention does not lie therein.

As better shown in FIG. **1**, each conductor **31** is secured to an opposite side **13**, **15** (or leg) of the device through a connector **34**. Connectors **34** can be any type of connector used in microwave devices, such as SMA or N, and preferably have a ground portion, which is secured, for example through screws, to the ends **13**, **15**. Consequently, the connector **34** is connected to conductor **31**, and the fixture including the ends **13**, **15**, the top **17**, blocks **25** and column **21** are all held at ground. It is for this reason that pressure columns **40** do not require to be made of an insulating material. The signal that will be applied to the conductor **31** will be almost completely isolated from the rest of the fixture. It should be noted that the above description for the connectors should not be taken as limitative, and that such connectors are well-known in the art.

The purpose of the invention is to provide an adjustable low-loss test fixture, so that the impedance of the transmission line going from the connector **34** to the device can be varied according to the device's specifications. By modifying the distance between the bottom surface **26** of the top **17** (or bridge) and the top surface **27** of the blocks, the impedance of the transmission line will vary and can be made to look like a 50 ohm line whatever DUT **100** is placed within the device **10**. Accordingly, a variety of different devices can be tested with the present invention, which is thus more versatile.

FIG. **3** is a schematic representation of the calibration set-up for the test fixture **10** of the present invention. The test fixture **10** is connected to a network analyser **200**, which receives as an input a signal from a signal generator **203**. The setup is optionally controlled by a computer **201**.

The scope of the invention as defined in the appended claims is directed, singly or in combination, to a dielectricless mechanical test fixture structure capable of handling high powers; a new mechanical approach based on brackets to secure and hold in place device packages flanges; a new overall geometry along the transitions, in which mismatches are compensated by vertical asymmetry of the transmission lines going from the brackets holding the device package flanges to the connectors; and a new method to adjust the inserts in the test-jigs so as to attain a characteristic impedance of 50 Ohms.

Although the present invention has been explained hereinabove by way of a preferred embodiment thereof, it should be pointed out that any modifications to this preferred embodiment within the scope of the appended claims is not deemed to alter or change the nature and scope of the present invention.

What is claimed is:

1. A low-loss microwave device test fixture, said device having at least two flanges lying on an axis and projecting on opposite directions from the device, and at least one ground flange, said test fixture comprising:

a frame having two opposite extremities, a top, a bottom, a height, and a width;

a device supporting column located between said opposite extremities, having a top surface lying below said top of said frame and adapted to receive said device, said column having a height less than said height of said frame;

two adjustable blocks, each located between the device supporting column and an opposite extremity, said blocks being vertically adjustable;

two brackets for receiving a flange from the device, the brackets lying above the column and the blocks, each bracket being secured to an opposite extremity of the frame;

means for securing said device to said column; and

means for securing said column and said blocks at a given vertical position.

2. A low-loss microwave device test fixture according to claim **1**, wherein each of said device supporting column, said adjustable blocks and said frame are provided with a vertical slot having a predetermined length, and wherein said means for securing said column and said blocks at a given vertical position include a bolt having at least one threaded opposite end, said bolt passing through each of the vertical slots and a nut adapted to tighten said bolt.

3. A low-loss microwave device test fixture according to claim **1**, wherein said means for securing said device to said column include pressure column extending downwardly from said frame towards said column for pressuring the at least one ground flange of the device on the column.

4. A low-loss microwave device test fixture comprising:

a frame having two opposite legs, a top, a bottom, a width and a height, said frame also including a bridge at the top thereof for joining the two opposite legs;

a central column adapted to receive a bottom surface of a device, including at least one ground flange, said column being vertically adjustable and being located between said two legs below said bridge;

two flange retaining brackets defining a signal path, each bracket being secured to an opposite leg, said brackets extending towards each other and lying between said column and said bridge;

a block located below each bracket and being vertically adjustable so as to modify the characteristic impedance along the signal path; and

means for securely retaining the blocks and the column in a given vertical position.

5. A low-loss microwave device test fixture according to claim **4**, wherein said flange retaining brackets include a longitudinal slot having a length, a width and being provided with pressure means for securely retaining a flange therein.

6. A low-loss microwave device test fixture according to claim **5**, wherein said pressure means include a screw.

7. A low-loss microwave device test fixture according to claim **5**, wherein said pressure means are defined by the shape of said slot tapering inwardly.

8. A low-loss microwave test fixture according to claim **5**, wherein said pressure means include at least one strip within said slot and a resilient member for pushing a free edge of said strip within said slot.

* * * * *