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Remarks:

Amended claims in accordance with Rule 137(2) EPC.

(54) **Directional coupling device**

(57) The directional coupling device for coupling transmission power in a main transmission line 10 with a coupled line 20. The directional coupling device comprises a coupling transmission line 20. The coupling

transmission line 20 is a stripline transmission line comprising a coupling conductive strip 40 supported by a suspended substrate 100. The suspended substrate 100 is arranged between the coupling strip 40 and the main transmission line 10.

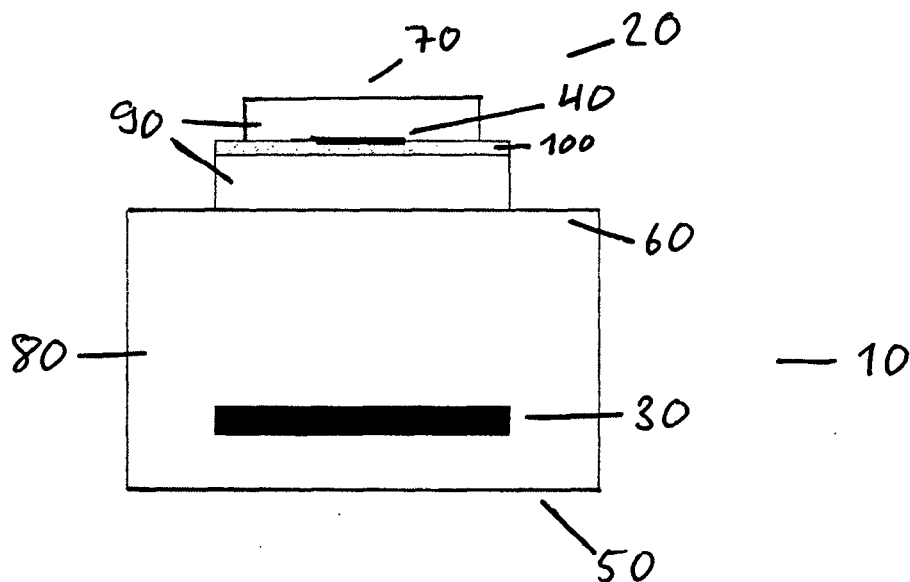


Fig. 2

Description

[0001] The present invention relates to a directional coupling device for coupling transmission power in a transmission line with a coupled line. Directional couplers are passive devices used in particular in the field of radio technology or microwave technology. They couple part of the transmission power in a transmission line by a prescribed amount out through another port by using two transmission lines set close enough together such that energy passing through one is coupled to the other.

[0002] A transmission line is any structure that forms a path for directing the transmission of energy, such as electromagnetic waves. A commonly used transmission line is a stripline transmission line. A stripline transmission line uses a flat strip conductor which is located between two parallel conducting ground planes. If the conductive strip is supported by a substrate, the stripline is called a suspended substrate stripline, without the substrate, the stripline is called an air stripline.

[0003] Directional coupling devices are commonly used as measurement devices on large high power radio frequency transmission lines. These directional coupling devices usually have a relatively weak coupling to the main transmission line; the coupling loss is usually about 30 dB. Furthermore, the directional coupling devices must have a high directivity. Directivity is the capacity of the directional coupling device to separate between the forward wave and the backward wave on the main transmission line.

[0004] A common approach for implementing a directional coupling device is the provision of a short air coupling stripline next to the main transmission line. However, this approach has several drawbacks. The coupling stripline must be placed in an exact position in relation to the main transmission line. Any deviation from the predetermined position negatively affects the provisioned coupling loss and reduces the directivity of the directional coupling device. Therefore, very low manufacturing tolerances must be achieved, which in turn means high production costs. Additionally, the positioning of the coupling conductive strip must be manually adjusted for each directional coupling device, which also means more labor and higher production costs.

Alternatively, suspended substrate stripline realizations of directional coupling devices have been proposed. The appended figure 1 shows a conventional arrangement of a suspended substrate coupling stripline located above a main air stripline transmission line. Figure 1 shows a main transmission line 10 and a coupling transmission line 20. The main transmission line 10 is an air stripline comprising a main conducting strip 30, a bottom conducting plane 50 and an intermediate conducting plane 60. The intermediate conducting plane 60 acts as top conducting plane for the main transmission line 10. The main conducting strip is arranged in a main cavity 80 of the main transmission line. The coupling transmission line 20 is arranged above the main transmission line 10. The

intermediate conducting plane 60, a coupling conductive strip 40 and a top conducting plane 70 each form part of the coupling transmission line 20. The intermediate conducting plane 60 constitutes the bottom conducting plane for the coupling transmission line 20. Reference sign 90 points to the coupling cavity, which houses the conductive strip. The coupling transmission line 20 is a suspended substrate stripline. A coupling strip support is provided within the coupling cavity 90. The coupling conductive strip is facing the intermediate conductive plane 60.

[0005] Conventionally, the coupling strip 40 is printed onto the coupling strip support using printed circuit board technology. Printed circuit boards are rugged, inexpensive, and can be highly reliable. Conducting layers are typically made of thin copper foil. Insulating layers are typically laminated together with epoxy resin (RF low-loss PCB material is usually Teflon). Printed circuit boards are made by bonding a layer of copper over the entire substrate, sometimes on both sides, then removing unwanted copper after applying a temporary mask (e.g. by etching), leaving only the desired copper traces. A few PCBs are made by adding traces to the bare substrate (or a substrate with a very thin layer of copper) usually by a complex process of multiple electroplating steps. Printed circuit board realization of the coupled stripline overcomes the problems related to the exact positioning of the conductive strip in the coupled transmission line. However, due to the relatively high dielectric constant of the printed circuit board material, the phase velocity in the coupled transmission line is different from the main transmission line. The difference in phase velocity is known to cause severe limitations in the directivity of the directional coupling device. Therefore, the advantages of a PCB stripline support are conventionally regarded as unavailable for directional coupling devices due to the problems related to phase velocity differences. In the case of measurement directional couplers for high power broadcast transmitters; the directivity must be very high.

[0006] Therefore, it is object of the present invention, to provide a directional coupling device, which provides precise high directivity coupling at a low cost.

[0007] The problem of the present invention is solved by the directional coupling device according to the appended claim 1. Accordingly, a directional coupling device is provided for coupling transmission power in a transmission line with a coupled transmission line. The directional coupling device comprises a coupling transmission line, which is a stripline transmission line. The stripline transmission line comprises a coupling conductive strip supported by a suspended substrate. Therefore, a suspended substrate stripline is utilized, which allows for exact positioning of the conductive strip relative to the main transmission line. Furthermore, the suspended substrate conductor layer of the stripline is arranged between the coupling line cavity and the main electromagnetic waveguide so that it faces the top conducting plane of the coupling line cavity. Consequently, the substrate no longer faces the main transmission line. In this con-

figuration, the coupled line phase velocity is near or equal to that on the main line and problems of poor directivity are overcome.

[0008] Preferably, the suspended substrate is a printed circuit board and the coupling conductive strip is printed onto the circuit board. Printed circuit boards are rugged, inexpensive, and can be highly reliable. Therefore, the production costs for the directional coupling device may be reduced without negatively affecting the directivity of the coupling device. The claimed invention enables to exploit the advantages of a printed circuit board support while avoiding the disadvantages of different phase velocities usually encountered with PCB type directional couplers.

[0009] The directional coupling device of the present invention is preferably implemented in three small directional couplers, which are arranged at the output strip-lines of 2-way to 8-way transmitter power amplifier combiners. The three small directional couplers are located at the output of the combiner. The coupled signals may be used for monitoring the standing wave ratio. A standing wave ratio (SWR) is a measure of the magnitude of the forward and reflected wave on a transmission line. The SWR is usually defined as a voltage ratio called the VSWR, for voltage standing wave ratio. The directional couplers may be used for measuring forward and reflected electromagnetic wave magnitudes in the main stripline and for monitoring the output signal. The VSWR can be derived mathematically from the measured forward and reflected wave magnitudes.

[0010] A preferred embodiment of the present invention is described in detail with reference to the accompanying drawings. Please note that the preferred embodiment merely represents a particular non-limiting implementation of the present invention. The gist and scope of the present invention is defined in the appended claims.

[0011] Figure 1 shows a conventional arrangement for a Directional Coupling device.

[0012] Figure 2 shows an arrangement of a directional coupling device according to the preferred embodiment of the present invention.

[0013] Figure 3 shows a view of the realized directional coupling device of Figure 2.

[0014] Figure 2 depicts the preferred embodiment of the present invention. In figure 2, a main transmission line 10 and a coupling transmission line 20 are displayed. The main transmission line 10 is an air stripline comprising a main conducting strip 30, a bottom conducting plane 50 and an intermediate conducting plane 60. The intermediate conducting plane 60 acts as top conducting plane for the main transmission line 10. The main conducting strip is arranged in a main cavity 80 of the main transmission line. The coupling transmission line 20 is arranged above the main transmission line 10. The intermediate conducting plane 60, a coupling conductive strip 40 and a top conducting plane 70 each form part of the coupling transmission line 20. Reference sign 90

points to the coupling cavity, which houses the conductive strip. The coupling transmission line 20 is a suspended substrate stripline. A coupling strip support is provided within the coupling cavity 90.

5 In the directional coupling device of the preferred embodiment, the suspended substrate is facing the intermediate conductive plane 60. Preferably, the suspended substrate (100) of the coupling transmission line is a printed circuit board, wherein the coupling conductive strip (40) is printed onto the suspended substrate (100) using PCB technology. Since the coupling conductive strip (40) is chosen opposite to the conventional orientation displayed in Figure 1, the coupled lines phase velocity is near or equal to that on the main line (10) and problems of poor directivity are overcome. Therefore, the preferred embodiment enables to exploit the advantages of printed circuit board support while avoiding the disadvantages of different phase velocities between the main transmission line (10) and the coupling transmission line (20).
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20 These differences usually severely reduce the directivity of the PCB type directional couplers.

[0015] In Figure 3 a view of the directional coupling device of the preferred embodiment is shown. The same reference signs characterize corresponding features in Figures 2 and 3. The main conducting strip 30 in Figure 3 is held in its place by an insulated fastener 110. The fastener 110 keeps the main conducting strip 30 elevated above the bottom conducting plane 50 within the main cavity 80 (Fig. 2) of the main transmission line 10. The intermediate conducting plane 60 is arranged between the main conducting strip 30 and the coupling conductive strip 40. A further mounting screw represents a fastener 130 for the PCB supporting the coupling conductive strip 40 within the coupling cavity 90. A top conducting plane 70 (Fig. 2) is placed above the coupling conductive strip 40. Finally, figure 3 shows connectors 120 for the coupling transmission line. These connectors 120 represent interfaces for coaxial transmission lines used for transferring electromagnetic waves. A second additional coupling device 140 is displayed next to reference sign 140.
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List of reference numerals

[0016]

45	10	main transmission line
	20	coupling transmission line
	30	main conducting strip
	40	coupling conductive strip
50	50	bottom conducting plane
	60	intermediate conducting plane
	70	top conducting plane
	80	main cavity
	90	coupling cavity
55	100	coupling strip support
	110	fastener for main conducting strip
	120	Connector for coupling conductive strip
	130	fastener for coupling conductive strip PCB

140 additional coupling device

the suspended substrate (100) is arranged between the coupling strip (40) and the main transmission line (10).

Claims

1. Directional Coupling device for coupling transmission power in a main transmission line (10) with a coupled line (20), comprising
a coupling transmission line (20), said coupling transmission line (20) being a stripline transmission line comprising a coupling conductive strip (40) supported by a suspended substrate (100),
characterized in that
the suspended substrate (100) is arranged between the coupling strip (40) and the main transmission line (10).
2. Directional coupling device according to claim 1, wherein the suspended substrate (100) is a printed circuit board and the coupling conductive strip (40) is printed onto the circuit board.
3. Directional coupling device according to claims 1 or 2, further comprising a main transmission line (10), said main transmission line being a stripline transmission line.
4. Directional coupling device according to claim 3, wherein the main transmission line (10) comprises a bottom conductive plane (50), a main conductive strip (30) and a top conductive plane (60), wherein the conductive strip (30) is positioned between the bottom and top conductive plane (50 and 60) and the top conductive plane (60) is facing the suspended substrate (100).

Amended claims in accordance with Rule 137(2) EPC.

1. Directional Coupling device for coupling transmission power in a main transmission line (10) with a coupled line (20),
wherein the main transmission line (10) comprises a bottom conductive plane (50), a main conductive strip (30) and a top conductive plane (60), wherein the conductive strip (30) is positioned between the bottom and top conductive plane (50 and 60) and the top conductive plane (60) is facing a suspended substrate (100); and said directional coupling device further comprising:

a coupling transmission line (20), said coupling transmission line (20) being a stripline transmission line comprising a coupling conductive strip (40) supported by said suspended substrate (100),
characterized in that

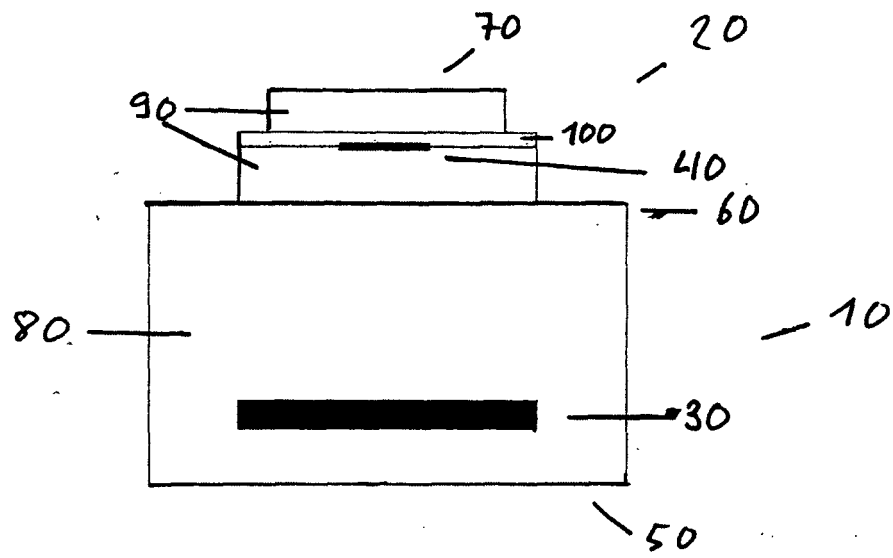


Fig. 1

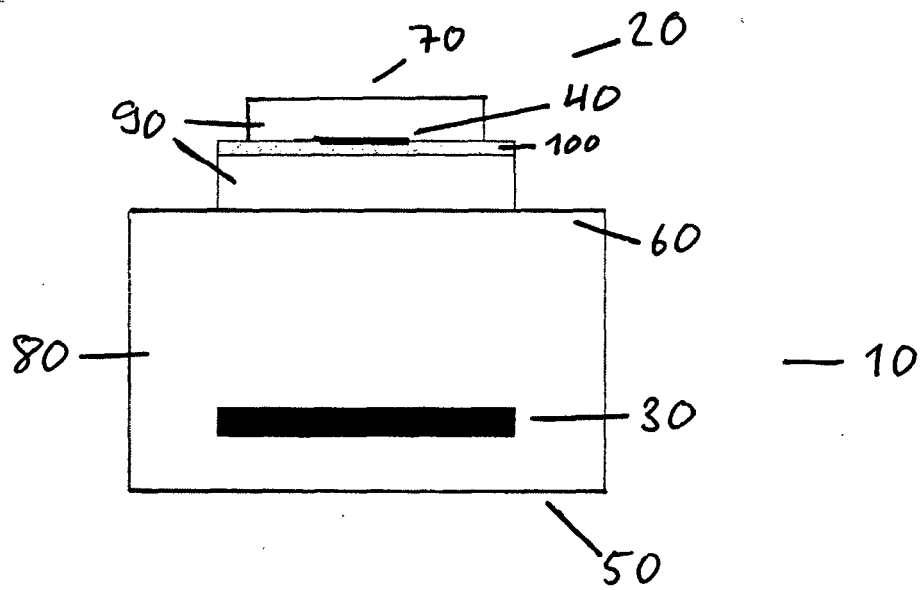


Fig. 2

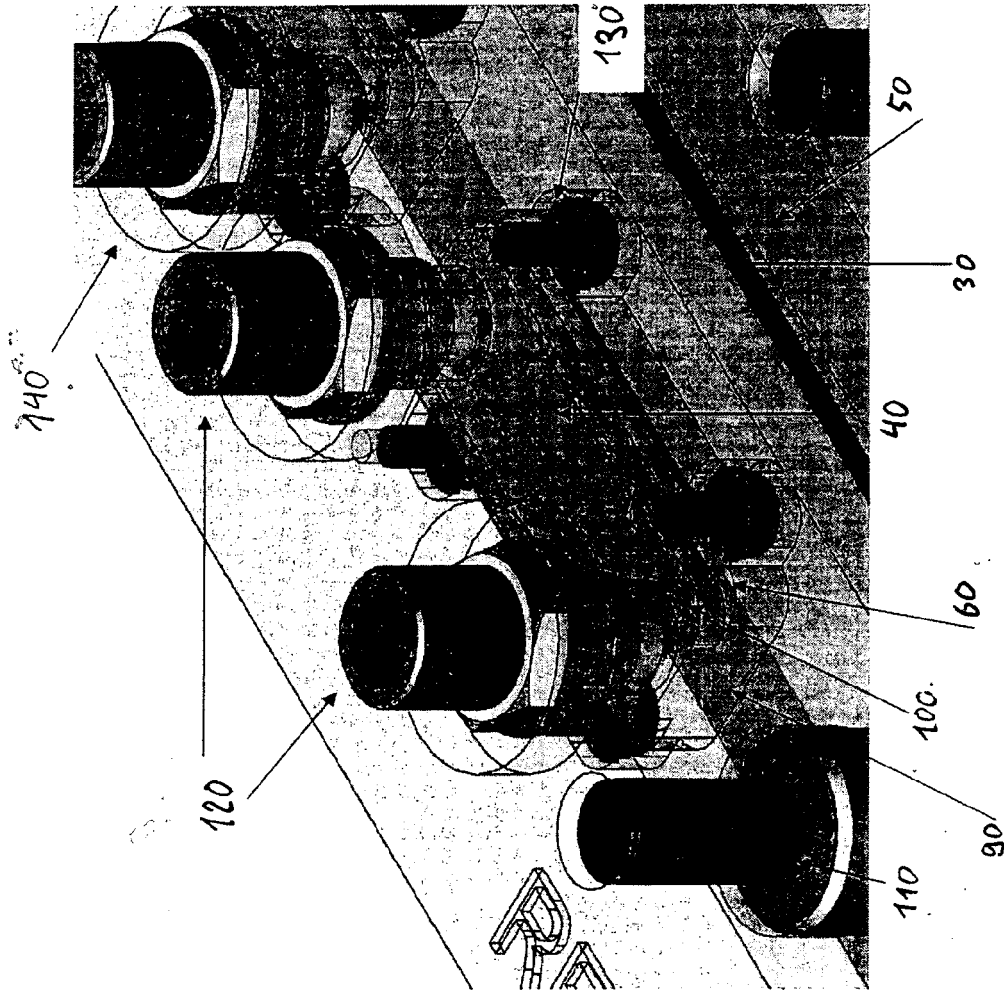


Fig. 3



EUROPEAN SEARCH REPORT

Application Number
EP 09 29 0041

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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
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Place of search		Date of completion of the search	Examiner
The Hague		26 May 2009	Pastor Jiménez, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 09 29 0041

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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