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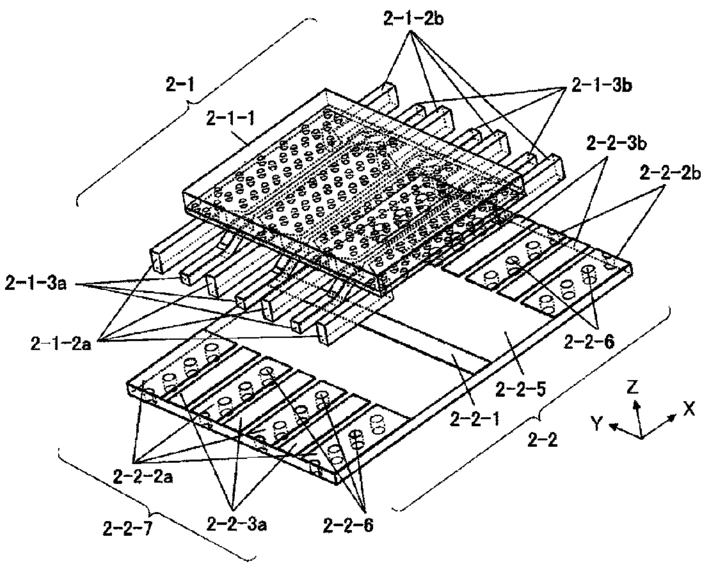
(54) Title: HIGH-FREQUENCY LINE CONNECTING STRUCTURE



(57) **Abrégé/Abstract:**
In the present invention, a high-frequency line substrate (2-1) is mounted on a printed board (2-2). The printed board (2-2) is provided with a first high-frequency line. The high-frequency line substrate (2-1) is provided with a second high-frequency line, and lead pins (2-1-2a, 2-1-2b, 2-1-3a, 2-1-3b) which connect the first high-frequency line and the second high-frequency line. In an abutting section between signal lead pins (2-1-3a, 2-1-3b) and the second high-frequency line of the high-frequency line substrate (2-1), and in an abutting section between ground lead pins (2-1-2a, 2-1-2b) and the second high-frequency line of the high-frequency line substrate (2-1), the heights of the ground lead pins (2-1-2a, 2-1-2b) from the upper surface of the printed board (2-2) are greater than the heights of the signal lead pins (2-1-3a, 2-1-3b).

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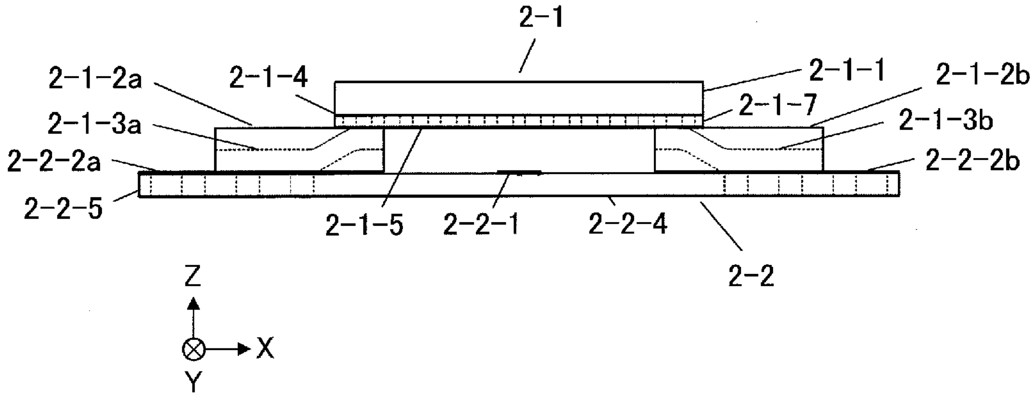
(54) Title: HIGH-FREQUENCY LINE CONNECTION STRUCTURE

(54) 発明の名称： 高周波線路接続構造



(57) Abstract: In the present invention, a high-frequency line substrate (2-1) is mounted on a printed board (2-2). The printed board (2-2) is provided with a first high-frequency line. The high-frequency line substrate (2-1) is provided with a second high-frequency line, and lead pins (2-1-2a, 2-1-2b, 2-1-3a, 2-1-3b) which connect the first high-frequency line and the second high-frequency line. In an abutting section between signal lead pins (2-1-3a, 2-1-3b) and the second high-frequency line of the high-frequency line substrate (2-1), and in an abutting section between ground lead pins (2-1-2a, 2-1-2b) and the second high-frequency line of the high-frequency line substrate (2-1), the heights of the ground lead pins (2-1-2a, 2-1-2b) from the upper surface of the printed board (2-2) are greater than the heights of the signal lead pins (2-1-3a, 2-1-3b).

WO 2021/084601 A1

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ZW), ユーラシア (AM, AZ, BY, KG, KZ, RU, TJ, TM), ヨーロッパ (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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(57) 要約：高周波線路基板（２－１）は、プリント基板（２－２）上に搭載される。プリント基板（２－２）は、第１の高周波線路を備える。高周波線路基板（２－１）は、第２の高周波線路と、第１の高周波線路と第２の高周波線路とを接続するリードピン（２－１－２ａ，２－１－２ｂ，２－１－３ａ，２－１－３ｂ）を備える。シグナルリードピン（２－１－３ａ，２－１－３ｂ）と高周波線路基板（２－１）の第２の高周波線路との当接部、およびグランドリードピン（２－１－２ａ，２－１－２ｂ）と高周波線路基板（２－１）の第２の高周波線路との当接部において、プリント基板（２－２）の上面からのグランドリードピン（２－１－２ａ，２－１－２ｂ）の高さは、シグナルリードピン（２－１－３ａ，２－１－３ｂ）よりも高い。

Description

Title of the Invention: HIGH-FREQUENCY LINE CONNECTING STRUCTURE

Technical Field

[0001] The present invention relates to a high-frequency line connecting structure for mounting a bridge substrate on a printed circuit board, crossing high-frequency lines of the printed circuit board three-dimensionally, and inserting electronic components into the high-frequency lines of the printed circuit board.

Background Art

[0002] When electrically connecting a plurality of various optoelectronic components on a printed circuit board having a limited area, the connections require a wider bandwidth of DC to 40 GHz. Furthermore, as seen in the recent progress of 1 Tbps optical communication technology, a wider bandwidth of 70 GHz or more is indispensable at the connections.

[0003] On the other hand, due to the economic efficiency thereof, the printed circuit board has been established as a platform used when mounting various optoelectronic components, and is widely used as a substrate on which optoelectronic components are to be mounted. When the printed circuit board is actually used, in order to prevent spatial interference between high-frequency lines and the optoelectronic components, a large number of methods have been adopted to bypass the high-frequency line to the inside of the printed circuit board, that is, an inner layer line. In such a structure where the high-frequency lines are bypassed to the inner layer line, the occurrence of an open stub is inevitable due to the structure. Traditionally, the effect of open stubs on high frequency characteristics has always been discussed.

[0004] The presence of open stubs in the high-frequency lines causes resonance due to the open stubs. Non-Patent Literature 1 discloses a transition of a stub resonance frequency to a high region by shortening the length of an open stub. By shortening the length of the open stub, the stub resonance frequency can be set to a frequency outside a roll-off frequency of a pass band, which is 20 GHz or more in the example described in Non-Patent Literature 1. However, it is physically difficult to eliminate the stub resonance itself, and the problem of roll-off of the pass characteristics due to the stub resonance remains.

[0005] On the other hand, Non-Patent Literature 2 discloses a method for shortening the length of an open stub by maximizing the machining accuracy of back drilling. However, the method disclosed in Non-Patent Literature 2 requires a high-precision processing technique, which causes a problem that the cost of the printed circuit board increases and the economic efficiency is impaired. Therefore, it has been difficult for the prior art to realize a wide bandwidth of DC to 70 GHz without impairing economic efficiency.

[0006] The problems of the prior art are described hereinafter in more detail. Fig. 18A is a plan view of a conventional multilayer printed circuit board, and Fig. 18B is a cross-sectional view taken along line A-A' of the multilayer printed circuit board of Fig. 18A. Two high-frequency lines, a differential microstrip line 101 and a single-phase coplanar line 102, are formed on an upper surface of a multilayer printed circuit board 100. The single-phase coplanar line 102 is composed of a signal line 103 and a ground plane 104 formed around the signal line 103. When a multilayer printed circuit board having a limited area is used, in some cases a plurality of high-frequency lines are provided in this manner.

[0007] The single-phase coplanar line 102 is divided into two parts at a section where the single-phase coplanar 102 intersects with the differential microstrip line 101. In order to connect the single-phase coplanar lines 102 arranged on the respective sides of the differential microstrip line 101, as shown in Fig. 18B, a structure is provided in which high-frequency signals are relayed by two vertical vias 105 of the multilayer printed circuit board 100 that are formed vertically and an inner layer line 106 of the multilayer printed circuit board 100 formed horizontally. Unnecessary parts of the vertical vias 105 are removed from a rear surface of the substrate by back drilling, which is one of the manufacturing processes of the multilayer printed circuit board.

[0008] In the example shown in Fig. 18B, holes 107 are formed by back drilling. Unfortunately, the formation of open stubs 108 is inevitable due to the limitation of machining accuracy. The presence of the open stubs 108 induces a resonance phenomenon when a high-frequency signal propagates to the inner layer line 106, affecting the pass characteristics of the single-phase coplanar line 102.

[0009] Fig. 19 is a diagram showing reflection loss characteristics and passage loss characteristics of the single-phase coplanar line 102 of the multilayer printed circuit board 100. Reference numeral 200 in Fig. 19 indicates the reflection loss characteristics, and reference numeral 201 indicates the passage loss characteristics. Due to the presence of the open stubs 108, a depression is generated in the passage loss characteristics at a specific resonance frequency (near 25 GHz in the example illustrated in Fig. 19), and the characteristics of suppressing the propagation of the high-frequency signal appear.

[0010] In order to realize a wide bandwidth of DC to 70 GHz, the stub length needs to be processed to 100 μm or less. However, in order to process the stub length to 100 μm or less, the accuracy of precision machining to obtain a stub length thinner than one insulating layer constituting the multilayer printed circuit board is required, and therefore it is difficult to shorten the stub length.

[0011] Therefore, a bridge substrate on which a high-frequency line is formed is mounted on a printed circuit board on which a coplanar line intersecting with a microstrip line is formed, and the coplanar lines divided at the portion where the coplanar line intersects with the microstrip line are connected via the high-frequency line of the bridge substrate, to three-dimensionally cross the microstrip line and the coplanar line. However, in such a three-dimensional crossing method using the bridge substrate, the connection portion between the bridge substrate and the printed circuit board is exposed to the air, so that a characteristic impedance of the connection portion increases as an electrical capacitance decreases, and there exists a problem that impedance mismatch between the coplanar line of the printed circuit board and the high frequency line of the bridge substrate occurs.

[0012] Furthermore, in order to realize an electrical connection in which the passage loss and the reflection loss are sufficiently suppressed in a wide bandwidth of DC to 70 GHz, a capacitor called a so-called DC block capacitor is inserted in series into the high-frequency line. When such a component as a DC block capacitor is mounted on the printed circuit board using the bridge substrate, since the connection portion between the bridge substrate and the printed circuit board is exposed to the air as described above, there is a problem that impedance mismatch between the coplanar line of the printed circuit board and the high frequency line of the bridge substrate occurs.

Citation List

Non-Patent Literature

[0013] Non-Patent Literature 1: Qinghua Bill Chen, Jianmin Zhang, Kelvin Qiu, Darja Padilla, Zhiping Yang, Antonio C. Scogna, Jun Fan, "Enabling Terabit Per Second Switch Linecard Design Through Chip/Package/PCB Co-design", on Proceedings of IEEE International Symposium on Electromagnetic Compatibility, July 2010, USA

Non-Patent Literature 2: Takahiro Yagi, Kiyoshi Koike, Hiroshi Iinaga, "Development of High-speed Transmission Printed Circuit Board," OKI Technical Review, p.36-p.39, Vol.82, 225, May, 2015

Summary of the Invention

Technical Problem

[0014] The present invention was contrived to solve the foregoing problems, and an object thereof is to provide a high-frequency line connecting structure capable of suppressing impedance mismatch caused by a connection portion between a bridge substrate and a printed circuit board when connecting a high-frequency line using the bridge substrate.

[0015] Another object of the present invention is to provide a high-frequency line connecting structure capable of suppressing impedance mismatch caused by a connection portion between a bridge substrate and a printed circuit board when mounting a component such as a DC block capacity using the bridge substrate.

Means for Solving the Problem

[0016] A high-frequency line connecting structure of the present invention includes a first substrate and a second substrate mounted on the first substrate, the first substrate including a first high-frequency line, the second substrate including a second high-frequency line and a lead pin made of a conductor that electrically connects the first high-frequency line and the second high-frequency line, the first high-frequency line including a first signal line formed on a first main surface of the first substrate and having a section divided into two in the middle, and a first ground formed on the first main surface of the first substrate along the first signal line and having a section where being divided into two, the section being at the same position in an extension direction as the section where the first signal line is divided, the second high-frequency line including a second signal line formed on a first main surface of the second substrate facing the first substrate so that an extension direction is parallel to the extension direction of the first signal line, and a second ground formed on the first main surface of the second substrate along the second signal line so that the extension direction is parallel to the extension direction of the first ground, the lead pin being composed of signal lead pins that are connected to both ends of the second signal line respectively so as to be in contact with one part of the first signal line and another part of the first signal line that are divided, in a state in which the second substrate is mounted on the first substrate in such a manner that the second signal line is positioned on the divided section of the first signal line and the second ground is positioned on the divided section of the first ground, and ground lead pins that are connected to both ends of the second ground respectively so as to be in contact with one part of the first ground and another part of the first ground that are divided, in a state in which the second substrate is mounted on the first substrate, wherein a height of the ground lead pin from the first main surface of the first substrate is greater than that of the signal lead pin at a contact portion between the signal lead pin and the first signal line and a contact portion between the ground lead pin and the first ground.

[0017] In one configuration example of the high-frequency line connecting structure of the present invention, the second substrate further includes a third high-frequency line formed on a second main surface of the second substrate that is on a side opposite to the first main surface, and an electronic component mounted on the second main surface of the second substrate and inserted in series into the third high-frequency line, the third high-frequency line including a third signal line formed on the second main surface of the second substrate and having a section divided into two in the middle, and a third ground formed on the second main surface of the second substrate so as to surround the third signal line, the electronic component having two electrodes connected to one part of the third signal line and another part of the third signal line that are divided, the second signal line of the second high-frequency line including a section divided into two in the middle, the second ground of the second high-frequency line being formed so as to surround the second signal line, both ends of the third signal line being connected to one part of the second signal line and another part of the second signal line that are divided, via vias formed on the second substrate.

[0018] In one configuration example of the high-frequency line connecting structure of the present invention, a plurality of the first signal lines of the first high-frequency line are arranged in parallel, a plurality of the first grounds of the first high-frequency line are arranged on both sides of the first signal lines along the first signal lines, a plurality of the second signal lines of the second high-frequency line are arranged in parallel, a plurality of the second grounds of the second high-frequency line are arranged on both sides of the second signal lines along the second signal lines, a plurality of the signal lead pins are arranged in parallel along an alignment direction of the first signal lines and the second signal lines, and a plurality of the ground lead pins are arranged in parallel along an alignment direction of the first grounds and the second grounds.

[0019] In one configuration example of the high-frequency line connecting structure of the present invention, a plurality of the first signal lines of the first high-frequency line are arranged in parallel, a plurality of the first grounds of the first high-frequency line are arranged on both sides of the first signal lines along the first signal lines, a plurality of the second signal lines of the second high-frequency line are arranged in parallel, a plurality of the second grounds of the second high-frequency line are arranged so as to surround the plurality of second signal lines, a plurality of the third signal lines of the third high-frequency line are arranged in parallel, the third ground of the third high-frequency line is arranged so as to surround a plurality of the third signal lines, the electronic component is provided for each of the third signal lines, a plurality of the signal lead pins are arranged in parallel along an alignment direction of the first signal lines, the second signal lines, and the third signal lines, and a plurality of the ground lead pins are arranged in parallel along an alignment direction of the first grounds and the second grounds.

In one configuration example of the high-frequency line connecting structure of the present invention, the electronic component is a DC block capacitor.

Effects of the Invention

[0020] According to the present invention, a structure is obtained in which, at the contact portions between the signal lead pins and the first signal lines and the contact portions between the ground lead pins and the first grounds, the height of the ground lead pins from the first main surface of the first substrate is made greater than that of the signal lead pins so that the ground lead pins each functioning as a ground of a high-frequency line surround the signal lead pins. With this structure, in the present invention, not only is it possible to prevent a decrease in capacitance between the signal lead pins and the ground lead pins, but also an increase in the characteristic impedance of the high-frequency lines can be suppressed. In the present invention, impedance matching between the first high-frequency line of the first substrate and the second high-frequency line of the second substrate can be achieved, and a crosstalk between a signal lead pin and an adjacent signal lead pin can be reduced. As a result, the present invention can provide a high-frequency line connecting structure capable of realizing low reflection loss characteristics, low passage loss characteristics, and low crosstalk characteristics in a wide bandwidth.

[0021] The present invention can also provide a high-frequency line connecting structure capable of realizing low reflection loss characteristics, low passage loss characteristics, and low crosstalk characteristics in a wide bandwidth by means of a configuration in which an electronic component is inserted in a first high-frequency line of a printed circuit board.

Brief Description of Drawings

[0022] [Fig. 1] Fig. 1 is an exploded perspective view of a high-frequency line connecting structure according to a first embodiment of the present invention.

[Fig. 2] Fig. 2 is an exploded perspective view of the high-frequency line connecting structure according to the first embodiment of the present invention.

[Fig. 3] Fig. 3 is a bottom view of the high-frequency line connecting structure according to the first embodiment of the present invention.

[Fig. 4] Fig. 4 is a perspective view of a high-frequency line connecting structure according to the first embodiment of the present invention.

[Fig. 5] Fig. 5 is a plan view of the high-frequency line connecting structure according to the first embodiment of the present invention.

[Fig. 6] Fig. 6 is a side view of the high-frequency line connecting structure according to the first embodiment of the present invention.

[Fig. 7] Fig. 7 is a diagram illustrating simulation results of reflection loss characteristics and passage loss characteristics of the high-frequency line connecting structure according to the first embodiment of the present invention.

[Fig. 8] Fig. 8 is a diagram illustrating simulation results of crosstalk characteristics between adjacent channels and passage loss characteristics of the high-frequency line connecting structure according to the first embodiment of the present invention.

[Fig. 9] Fig. 9 is an exploded perspective view of a high-frequency line connecting structure according to a second embodiment of the present invention.

[Fig. 10] Fig. 10 is an exploded perspective view of the high-frequency line connecting structure according to the second embodiment of the present invention.

[Fig. 11] Fig. 11 is a bottom view of a high-frequency line substrate of the high-frequency line connecting structure according to the second embodiment of the present invention.

[Fig. 12] Fig. 12 is a plan view of the high-frequency line substrate of the high-frequency line connecting structure according to the second embodiment of the present invention.

[Fig. 13] Fig. 13 is a perspective view of the high-frequency line connecting structure according to the second embodiment of the present invention.

[Fig. 14] Fig. 14 is a plan view of the high-frequency line connecting structure according to the second embodiment of the present invention.

[Fig. 15] Fig. 15 is a side view of the high-frequency line connecting structure according to the second embodiment of the present invention.

[Fig. 16] Fig. 16 is a diagram illustrating simulation results of reflection loss characteristics and passage loss characteristics of the high-frequency line connecting structure according to the second embodiment of the present invention.

[Fig. 17] Fig. 17 is a diagram illustrating simulation results of crosstalk characteristics between adjacent channels and passage loss characteristics of the high-frequency line connecting structure according to the second embodiment of the present invention.

[Fig. 18A] Fig. 18A is a plan view of a multilayer printed circuit board of the prior art.

[Fig. 18B] Fig. 18B is a cross-sectional view of the multilayer printed circuit board of the prior art.

[Fig. 19] Fig. 19 is a diagram illustrating reflection loss characteristics and passage loss characteristics of the multilayer printed circuit board of the prior art.

Description of Embodiments

[0023] Embodiments of the present invention are described hereinafter in detail with reference to the drawings.

[0024] [First Embodiment]

Fig. 1 is an exploded perspective view showing, from above, a high-frequency line connecting structure according to a first embodiment of the present invention, and Fig. 2 is an exploded perspective view showing the high-frequency line connecting structure from below. As shown in Figs. 1 and 2, a printed circuit board 2-2 (first substrate) includes a flat plate-shaped dielectric 2-2-5, a microstrip line 2-2-1 made of a conductor that is formed on an upper surface (first main surface) of the dielectric 2-2-5, signal lines 2-2-3a and 2-2-3b (first signal lines) made of conductors that are formed on the upper surface of the dielectric 2-2-5 along a direction intersecting with the microstrip lines 2-2-1, ground planes 2-2-2a and 2-2-2b (first grounds) made of conductors that are formed on the upper surface of the dielectric 2-2-5 along the signal lines 2-2-3a and 2-2-3b, a ground plane 2-2-4 made of a conductor that is formed on a lower surface (second main surface) of the dielectric 2-2-5, and ground vias 2-2-6 made of conductors that connect the ground planes 2-2-2a and 2-2-2b to the ground plane 2-2-4.

[0025] In the present embodiment, a plurality of the signal lines 2-2-3a are arranged in parallel. A plurality of the ground planes 2-2-2a are arranged on both sides of the signal lines 2-2-3a along the signal lines 2-2-3a. Similarly, a plurality of the signal lines 2-2-3b are arranged in parallel. A plurality of the ground planes 2-2-2b are arranged on both sides of the signal lines 2-2-3b along the signal lines 2-2-3b.

[0026] The signal lines 2-2-3a and the signal lines 2-2-3b are divided at the intersections thereof with the microstrip line 2-2-

1. Similarly, the ground planes 2-2-2a and the ground planes 2-2-2b are divided at sections which are at the same position in extension direction (X direction in Figs. 1 and 2) as the sections where the signal lines 2-2-3a and 2-2-3b are divided.

[0027] The ground planes 2-2-2a and 2-2-2b are electrically connected to the ground plane 2-2-4 by the ground vias 2-2-6 formed on the dielectric 2-2-5.

[0028] The signal lines 2-2-3a and 2-2-3b and the ground planes 2-2-2a and 2-2-2b constitute a grounded coplanar line 2-2-7 (first high-frequency line) having the ground plane 2-2-4 on a rear surface of the substrate. As described above, the grounded coplanar line 2-2-7 is divided at the intersection thereof with the microstrip line 2-2-1.

[0029] Next is described a high-frequency line substrate 2-1 (second substrate) for connecting the divided grounded coplanar lines 2-2-7 located on both sides of the microstrip line 2-2-1. Fig. 3 is a bottom view of the high-frequency line substrate 2-1. In Fig. 3, the descriptions of the signal lead pins and the ground lead pins, which will be described later, are omitted in order to facilitate understanding of the configuration of the high-frequency line substrate 2-1.

[0030] As shown in Figs. 1 to 3, the high-frequency line substrate 2-1 includes a flat plate-shaped dielectric 2-1-1, a ground plane 2-1-4 made of a conductor that is formed on a lower surface of the dielectric 2-1-1 facing the printed circuit board 2-2, a dielectric 2-1-7 formed on a lower surface of the ground plane 2-1-4 facing the printed circuit board 2-2, a signal line 2-

1-6 (second signal line) made of a conductor that is formed on a lower surface (first main surface) of the dielectric 2-1-7 facing the printed circuit board 2-2, so that the extension direction becomes parallel to the extension direction of the signal lines 2-2-3a and 2-2-3b when the high-frequency line substrate 2-1 is mounted on the printed circuit board 2-2, and a ground plane 2-1-5 (second ground) made of a conductor that is formed on the lower surface of the dielectric 2-1-7 facing the printed circuit board 2-2, along the signal line 2-1-6, so that the extension direction becomes parallel to the extension direction of the ground planes 2-2-2a and 2-2-2b when the high-frequency line substrate 2-1 is mounted on the printed circuit board 2-2.

[0031] The high-frequency line substrate 2-1 further includes signal lead pins 2-1-3a and 2-1-3b made of conductors that are connected to both ends of the signal line 2-1-6 respectively so as to be in contact with the signal lines 2-2-3a and 2-2-3b when the high-frequency line substrate 2-1 is mounted on the printed circuit board 2-2, ground lead pins 2-1-2a and 2-1-2b made of conductors that are connected to both ends of the ground plane 2-1-5 respectively so as to be in contact with the ground planes 2-2-2a and 2-2-2b when the high-frequency line substrate 2-1 is mounted on the printed circuit board 2-2, and ground vias 2-1-8 made of conductors that are formed in the dielectric 2-1-7 and connect the ground plane 2-1-4 and the ground plane 2-1-5.

[0032] Examples of the material of the dielectrics 2-1-1, 2-1-7, and 2-2-5 include low-loss ceramics such as alumina.

In the present embodiment, a plurality of the signal lines 2-1-6 are arranged in parallel on the lower surface of the high-frequency line substrate 2-1. The pitch of the signal lines 2-1-6 in the alignment direction (Y direction in Figs. 1 to 3) is the same as the pitch of the signal lines 2-2-3a and 2-2-3b in the alignment direction.

[0033] A plurality of the ground planes 2-1-5 are arranged on both sides of the signal lines 2-1-6 along the signal lines 2-1-6. The pitch of the ground planes 2-1-5 in the alignment direction is the same as the pitch of the ground planes 2-2-2a and 2-2-2b in the alignment direction.

[0034] The ground planes 2-1-5 are electrically connected to the ground planes 2-1-4 by the ground vias 2-1-8 formed on the dielectric 2-1-7.

The signal lines 2-1-6 and the ground planes 2-1-5 constitute a grounded coplanar line 2-1-9 (second high-frequency line) having the ground plane 2-1-4 on the opposite side with the dielectric 2-1-7 therebetween.

[0035] In the present embodiment, a plurality of the signal lead pins 2-1-3a and 2-1-3b are arranged in parallel along the alignment direction of the signal lines 2-2-3a and 2-2-3b and the alignment direction (Y direction in Figs. 1 to 3) of the signal lines 2-1-6. The pitch of the signal lead pins 2-1-3a and 2-1-3b in the alignment direction is the same as the pitch of the signal lines 2-2-3a and 2-2-3b and the signal lines 2-1-6 in the alignment direction.

[0036] A plurality of the ground lead pins 2-1-2a and 2-1-2b are arranged in parallel along the alignment direction of the ground planes 2-2-2a and 2-2-2b and the alignment direction (Y direction in Figs. 1 to 3) of the ground planes 2-1-5. The pitch of the ground lead pins 2-1-2a and 2-1-2b in the alignment direction is the same as the pitch of the ground planes 2-2-2a and 2-2-2b and the ground planes 2-1-5 in the alignment direction.

[0037] Examples of a method for fixing the signal lead pins 2-1-3a and 2-1-3b to the signal lines 2-1-6 and a method for fixing the ground lead pins 2-1-2a and 2-1-2b to the ground planes 2-1-5 include brazing and soldering; needless to say, other fixing methods may be adopted.

[0038] After the high-frequency line substrate 2-1 and the printed circuit board 2-2 described above are individually prepared, the high-frequency line substrate 2-1 is mounted on the printed circuit board 2-2.

Fig. 4 is a perspective view of a high-frequency line connecting structure in which the high-frequency line substrate 2-1 is mounted on the printed circuit board 2-2, and the divided grounded coplanar lines 2-2-7 of the printed circuit board 2-2 are connected by the grounded coplanar line 2-1-9 of the high-frequency line substrate 2-1. Fig. 5 is a plan view of the high-frequency line connecting structure of Fig. 4, and Fig. 6 is a side view of the high-frequency line connecting structure of Fig. 4.

[0039] In order to prepare the high-frequency line connecting structure shown in Figs. 4 to 6, the surface of the high-frequency line substrate 2-1 on which the signal lines 2-1-6 and the ground planes 2-1-5 are formed is placed face-down so the signal lines 2-1-6 are positioned above the divided sections of the signal lines 2-2-3a and 2-2-3b and the ground planes 2-1-5 are positioned on the divided sections of the ground planes 2-2-2a and 2-2-2b, and then the high-frequency line substrate 2-1 is mounted on the printed circuit board 2-2.

[0040] In so doing, the high-frequency line substrate 2-1 is mounted on the printed circuit board 2-2 in such a manner that the signal lead pins 2-1-3a and 2-1-3b of the high-frequency line substrate 2-1 and the signal lines 2-2-3a and 2-2-3b of the printed circuit board 2-2 come into contact with each other, and that the ground lead pins 2-1-2a and 2-1-2b of the high-frequency line substrate 2-1 and the ground planes 2-2-2a and 2-2-2b of the printed circuit board 2-2 come into contact with each other.

[0041] The signal lead pins 2-1-3a and 2-1-3b of the high-frequency line substrate 2-1 and the signal lines 2-2-3a and 2-2-3b of the printed circuit board 2-2 are connected by soldering or the like. Similarly, the ground lead pins 2-1-2a and 2-1-2b of the high-frequency line substrate 2-1 and the ground planes 2-2-2a and 2-2-2b of the printed circuit board 2-2 are connected by soldering or the like.

[0042] With the high-frequency line connecting structure described above, the signal line 2-2-3a of the printed circuit board 2-2 is electrically connected to the signal line 2-2-3b via the signal lead pin 2-1-3a, the signal line 2-1-6, and the signal lead pin 2-1-3b of the high-frequency line substrate 2-1.

Similarly, the ground plane 2-2-2a of the printed circuit board 2-2 is electrically connected to the ground plane 2-2-2b via the ground lead pin 2-1-2a, the ground plane 2-1-5, and the ground lead pin 2-1-2b of the high-frequency line substrate 2-1. In the present embodiment, the microstrip line 2-2-1 and the grounded coplanar line 2-2-7 formed on the upper surface of the printed circuit board 2-2 can be crossed three-dimensionally.

[0043] In the present embodiment, as shown in Fig. 6, the shapes of the ground lead pins 2-1-2a and 2-1-2b and of the signal lead pins 2-1-3a and 2-1-3b are determined in such a manner that the height of the ground lead pins 2-1-2a and 2-1-2b from the upper surface of the printed circuit board 2-2 is greater than that of the signal lead pins 2-1-3a and 2-1-3b at the contact portions between the signal lead pins 2-1-3a and 2-1-3b and the signal lines 2-2-3a and 2-2-3b, and the contact portions between the ground lead pins 2-1-2a and 2-1-2b and the ground planes 2-2-2a and 2-2-2b.

[0044] As is clear from Fig. 6, needless to say, the height of upper surfaces of the signal lead pins 2-1-3a and 2-1-3b at the connection portions between the signal lead pins 2-1-3a and 2-1-3b and the signal lines 2-1-6 is the same as the height of the upper surfaces of the ground lead pins 2-1-2a and 2-1-2b at the connection portions between the ground lead pins 2-1-2a and 2-1-2b and the ground planes 2-1-5. The signal lead pins 2-1-3a and 2-1-3b are shaped such that the upper surfaces thereof become lower in height from the high-frequency line substrate 2-1 toward the signal lines 2-2-3a and 2-2-3b, respectively.

[0045] A high-frequency signal propagates from the printed circuit board 2-2 to the high-frequency line substrate 2-1 through the signal lead pin 2-1-3a. Furthermore, a high-frequency signal propagates from the high-frequency line substrate 2-1 to the printed circuit board 2-2 through the signal lead pin 2-1-3b. In such a case, since the signal lead pins 2-1-3a and 2-1-3b are exposed to the air, the capacitance between the signal lead pins 2-1-3a and 2-1-3b and the ground lead pins 2-1-2a and 2-1-2b decreases, and the characteristic impedance of the coplanar line tends to increase.

[0046] In the present embodiment, at the contact portions between the signal lead pins 2-1-3a and 2-1-3b and the signal lines 2-2-3a and 2-2-3b, and the contact portions between the ground lead pins 2-1-2a and 2-1-2b and the ground planes 2-2-2a and 2-2-2b, the height of the ground lead pins 2-1-2a and 2-1-2b is made greater than that of the signal lead pins 2-1-3a and 2-1-3b. Thus, a structure is obtained in which the signal lead pins 2-1-3a and 2-1-3b are surrounded by the ground lead pins 2-1-2a and 2-1-2b that each function as the ground of the coplanar line.

[0047] With this structure, in the present embodiment, not only is it possible to prevent a decrease in capacitance between the signal lead pins 2-1-3a and 2-1-3b and the ground lead pins 2-1-2a and 2-1-2b, but also an increase in the characteristic impedance of the coplanar lines can be suppressed. As a result, impedance matching can be achieved between the grounded coplanar line 2-2-7 of the printed circuit board 2-2 and the grounded coplanar line 2-1-9 of the high-frequency line substrate 2-1.

[0048] In addition, in the present embodiment, the ground lead pins 2-1-2a and 2-1-2b can enclose a line of electric force from the signal lead pins 2-1-3a and 2-1-3b so as not to leak the line of electric force to the adjacent signal lead pins 2-1-3a and 2-1-3b. As a result, crosstalk between the signal lead pins 2-1-3a and 2-1-3b and the adjacent signal lead pins 2-1-3a and 2-1-3b can be reduced.

[0049] Fig. 7 is a diagram illustrating simulation results of reflection loss characteristics and passage loss characteristics of the grounded coplanar line in the high-frequency line connecting structure of the present embodiment. Fig. 8 is a diagram illustrating simulation results of crosstalk characteristics between adjacent channels and passage loss characteristics of the grounded coplanar line in the high-frequency line connecting structure of the present embodiment.

[0050] Reference numeral 700 in Figs. 7 and 8 indicates the reflection loss characteristics, and reference numeral 701 indicates the passage loss characteristics. Reference numeral 702 of Fig. 8 indicates a crosstalk between adjacent channels occurring when the shape of the ground lead pins 2-1-2a and 2-1-2b is identical to that of the signal lead pins 2-1-3a and 2-1-3b, and reference numeral 703 indicates a crosstalk between adjacent channels in the present embodiment.

[0051] In the present embodiment, by mounting the high-frequency line substrate 2-1 on the printed circuit board 2-2, the grounded coplanar lines 2-2-7 divided at the intersection thereof with the microstrip line 2-2-1 are connected via the high-frequency line substrate 2-1. Also in the present embodiment, by making the height of the ground lead pins 2-1-2a and 2-1-2b at the connection portion with the printed circuit board 2-2 greater than that of the signal lead pins 2-1-3a and 2-1-3b, impedance matching can be achieved between the grounded coplanar line 2-2-7 of the printed circuit board 2-2 and the grounded coplanar line 2-1-9 of the high-frequency line substrate 2-1.

[0052] As a result, in the present embodiment, the high-frequency line connecting structure capable of achieving favorable effects as shown in Figs. 7 and 8 and realizing low reflection loss characteristics, low passage loss characteristics, and low crosstalk characteristics in a wide band, can be obtained.

[0053] [Second Embodiment]

A second embodiment of the present invention is described next. Fig. 9 is an exploded perspective view showing, from above, a high-frequency line connecting structure according to the second embodiment of the present invention. Fig. 10 is an exploded perspective view showing the high-frequency line connecting structure of Fig. 9 from below. Fig. 11 is a bottom view of the high-frequency line substrate. Fig. 12 is a plan view of the high-frequency line substrate. Note that, in Fig. 11, the descriptions of the signal lead pins and the ground lead pins are omitted in order to facilitate understanding of the configuration of the high-frequency line substrate. Also in Fig. 12, the description of the DC block capacitor is omitted in order to facilitate understanding of the configuration of the high-frequency line substrate.

[0054] Fig. 13 is a perspective view of the high-frequency line connecting structure in which a high-frequency line substrate is mounted on a printed circuit board, and a grounded coplanar line of the printed circuit board is connected by a grounded coplanar line of the high-frequency line substrate. Fig. 14 is a plan view of the high-frequency line connecting structure of Fig. 13, and Fig. 15 is a side view of the high-frequency line connecting structure of Fig. 13.

[0055] A printed circuit board 3-2 (first substrate) of the present embodiment includes a flat plate-shaped dielectric 3-2-5, signal lines 3-2-3a and 3-2-3b (first signal lines) made of conductors that are formed on an upper surface (first main surface) of the dielectric 3-2-5, ground planes 3-2-2a and 3-2-2b (first grounds) made of conductors that are formed on the upper surface of the dielectric 3-2-5 along the signal lines 3-2-3a and 3-2-3b, a ground plane 3-2-4 made of a conductor that is formed on a lower surface (second main surface) of the dielectric 3-2-5, and ground vias 3-2-6 made of conductors that connect the ground planes 3-2-2a and 3-2-2b to the ground plane 3-2-4.

[0056] In the present embodiment, a plurality of the signal lines 3-2-3a are arranged in parallel. A plurality of the ground planes 3-2-2a are arranged on both sides of the signal lines 3-2-3a along the signal lines 3-2-3a. Similarly, a plurality of the signal lines 3-2-3b are arranged in parallel. A plurality of ground planes 3-2-2b are arranged on both sides of the signal lines 3-2-3b along the signal lines 3-2-3b.

[0057] The signal lines 3-2-3a and the signal lines 3-2-3b are divided at the position where a DC block capacitor is mounted as described hereinafter. Similarly, the ground planes 3-2-2a and the ground planes 3-2-2b are divided at sections which are at the same position in the extension direction (X direction in Figs. 9 to 15) as the sections where the signal lines 3-2-3a and 3-2-3b are divided.

[0058] The ground planes 3-2-2a and 3-2-2b are electrically connected to the ground plane 3-2-4 by the ground vias 3-2-6 formed on the dielectric 3-2-5.

[0059] The signal lines 3-2-3a and 3-2-3b and the ground planes 3-2-2a and 3-2-2b constitute a grounded coplanar line 3-2-7 (first high-frequency line) having the ground plane 3-2-4 on a rear surface of the substrate. The grounded coplanar line 3-2-7 is divided at a section where the high-frequency line substrate is mounted, in order to insert the DC block capacitor in series as described hereinafter.

[0060] On the other hand, the high-frequency line substrate 3-1 (second substrate) includes a flat plate-shaped dielectric 3-1-1, signal lines 3-1-6a and 3-1-6b (second signal lines) made of conductors that are formed on a lower surface (first main surface) of the dielectric 3-1-1 facing the printed circuit board 3-2 so that the extension direction becomes parallel to the extension direction of the signal lines 3-2-3a and 3-2-3b when the high-frequency line substrate 3-1 is mounted on the printed circuit board 3-2, a ground plane 3-1-5 (second ground) made of a conductor that is formed on the lower surface of the dielectric 3-

1-1 facing he printed circuit board 3-2 so as to surround the signal line 3-1-6a and 3-1-6b, signal lines 3-1-7a and 3-1-7b (third signal lines) made of conductors that are formed on an upper surface (second main surface) of the dielectric 3-1-1, and a ground plane 3-1-4 (third ground) formed on the upper surface of the dielectric 3-1-1 so as to surround the signal lines 3-1-7a and 3-1-7b.

[0061] The high-frequency line substrate 3-1 further includes signal lead pins 3-1-3a and 3-1-3b made of conductors that are connected to the signal lines 3-1-6a and 3-1-6b respectively so as to be in contact with the signal lines 3-2-3a and 3-2-3b when the high-frequency line substrate 3-1 is mounted on the printed circuit board 3-2, ground lead pins 3-1-2a and 3-1-2b made of conductors that are connected to both ends of the ground plane 2-1-5 respectively so as to be in contact with the ground planes 3-2-2a and 3-2-2b when the high-frequency line substrate 3-1 is mounted on the printed circuit board 3-2, ground vias 3-1-8 made of conductors that are formed on the dielectric 3-1-1 and connect the ground plane 3-1-4 and the ground plane 3-1-5 to each other, vias 3-1-9a and 3-1-9b made of conductors that are formed on the dielectric 3-1-1 and connect the signal lines 3-1-6a and 3-1-6b and the signal lines 3-1-7a and 3-1-7b to each other, and a DC block capacitor 3-1-10 (electronic component).

[0062] Examples of the material of the dielectrics 3-1-1 and 3-2-5 include low-loss ceramics such as alumina.

In the present embodiment, a plurality of the signal lines 3-1-6a are arranged in parallel on the lower surface of the high-frequency line substrate 3-1. Similarly, a plurality of the signal lines 3-1-6b are arranged in parallel. The ground planes 3-1-5 are arranged so as to surround the signal lines 3-1-6a and 3-1-6b. The signal lines 3-1-6a and the signal lines 3-1-6b are divided in order to mount the DC block capacitor 3-1-10 on the opposite surface. The pitch of the signal lines 3-1-6a and 3-1-6b in the alignment direction (Y direction in FIGS. 9 to 15) is the same as the pitch of the signal lines 3-2-3a and 3-2-3b in the alignment direction.

[0063] In the present embodiment, a plurality of the signal lines 3-1-7a are arranged in parallel on the upper surface of the high-frequency line substrate 3-1. Similarly, a plurality of the signal lines 3-1-7b are arranged in parallel. The ground planes 3-1-4 are arranged so as to surround the signal lines 3-1-7a and 3-1-7b. The signal lines 3-1-7a and the signal lines 3-1-7b are divided in order to mount the DC block capacitor 3-1-10 on the upper surface of the high-frequency line substrate 3-1. The pitch of the signal lines 3-1-7a and 3-1-7b in the alignment direction (Y direction in Figs. 9 to 15) is the same as the pitch of the signal lines 3-1-6a and 3-1-6b in the alignment direction.

[0064] The ground planes 3-1-5 are electrically connected to the ground planes 3-1-4 by the ground vias 3-1-8 formed on the dielectric 3-1-1.

Ends of the signal lines 3-1-7a are electrically connected to one of the two parts of the second signal line (signal line 3-1-6a) via the via 3-1-9a formed in the dielectric 3-1-1. Ends of the signal lines 3-1-7b are electrically connected to the other one of the two parts of the second signal line (signal line 3-1-6b) via the vias 3-1-9b formed in the dielectric 3-1-1.

[0065] The ground planes 3-1-5 are formed around the signal lines 3-1-6a and 3-1-6b, and the ground planes 3-1-4 are formed around the signal lines 3-1-7a and 3-1-7b. Thus, the signal lines 3-1-6a and 3-1-7a, the vias 3-1-9a, and the ground planes 3-1-4 and 3-1-5 constitute a pseudo-coaxial line structure 3-1-13a formed along a vertical direction of the high-frequency line substrate 3-1 (dielectric 3-1-1). Similarly, the signal lines 3-1-6b and 3-1-7b, the vias 3-1-9b, and the ground planes 3-1-4 and 3-1-5 constitute a pseudo-coaxial line structure 3-1-13b.

[0066] The signal lines 3-1-6a and 3-1-6b and the ground planes 3-1-5 constitute a grounded coplanar line 3-1-11 (second high-frequency line) having the ground planes 3-1-4 on the opposite side with the dielectric 3-1-1 therebetween. The grounded coplanar line 3-1-11 is divided into two in order to insert the DC block capacitor 3-1-10 in series.

[0067] The signal lines 3-1-7a and 3-1-7b and the ground plane 3-1-4 constitute a grounded coplanar line 3-1-12 (third high-frequency line) having the ground plane 3-1-5 on the opposite side with the dielectric 3-1-1 therebetween. The grounded coplanar line 3-1-12 is divided into two in order to insert the DC block capacitor 3-1-10 in series.

[0068] One electrode of the DC block capacitor 3-1-10 is soldered to one of the two divided sections of the third signal line (signal line 3-1-7a). The other electrode of the DC block capacitor 3-1-10 is soldered to the other part (signal line 3-1-

7b) of the two divided sections of the third signal line. In this manner, the DC block capacitor 3-1-10 is mounted on the high-frequency line substrate 3-1 and the DC block capacitor 3-1-10 is inserted in series into the grounded coplanar lines 3-1-11 and 3-1-12.

[0069] Examples of a method for fixing the signal lead pins 3-1-3a and 3-1-3b to the signal lines 3-1-6a and 3-1-6b and a method for fixing the ground lead pins 3-1-2a and 3-1-2b to the ground planes 3-1-5 include brazing and soldering; needless to say, other fixing methods may be adopted.

[0070] After the high-frequency line substrate 3-1 and the printed circuit board 3-2 described above are individually prepared, the high-frequency line substrate 3-1 is mounted on the printed circuit board 3-2.

In order to prepare the high-frequency line connecting structure shown in Figs. 13 to 15, the surface of the high-frequency line substrate 3-1 on which the signal lines 3-1-6a and 3-1-6b and the ground planes 3-1-5 are formed is placed face-down so the signal lines 3-1-6a, 3-1-6b, 3-1-7a, and 3-1-7b are positioned above the divided section of the signal lines 3-2-3a and 3-2-3b and the ground planes 3-1-5 and 3-1-4 are positioned on the divided section of the ground planes 3-2-2a and 3-2-2b, and then the high-frequency line substrate 3-1 is mounted on the printed circuit board 3-2.

[0071] In so doing, the high-frequency line substrate 3-1 is mounted on the printed circuit board 3-2 in such a manner that the signal lead pins 3-1-3a and 3-1-3b of the high-frequency line substrate 3-1 and the signal lines 3-2-3a and 3-2-3b of the printed circuit board 3-2 come into contact with each other, and that the ground lead pins 3-1-2a and 3-1-2b of the high-frequency line substrate 3-1 and the ground planes 3-2-2a and 3-2-2b of the printed circuit board 3-2 come into contact with each other.

[0072] The signal lead pins 3-1-3a and 3-1-3b of the high-frequency line substrate 3-1 and the signal lines 3-2-3a and 3-2-3b of the printed circuit board 3-2 are connected by soldering or the like. Similarly, the ground lead pins 3-1-2a and 3-1-2b of the high-frequency line substrate 3-1 and the ground planes 3-2-2a and 3-2-2b of the printed circuit board 3-2 are connected by soldering or the like.

[0073] With the high-frequency line connecting structure described above, the signal line 3-2-3a of the printed circuit board 3-2 is electrically connected to the signal line 3-2-3b via the signal lead pin 3-1-3a, the signal line 3-1-6a, the via 3-1-9a, the signal line 3-1-7a, the DC block capacitor 3-1-10, the signal line 3-1-7b, the via 3-1-9b, the signal line 3-1-6b and the signal lead pin 3-1-3b of the high-frequency line substrate 3-1.

[0074] The ground plane 3-2-2a of the printed circuit board 3-2 is electrically connected to the ground plane 3-2-2b via the ground lead pin 3-1-2a, the ground plane 3-1-5, and the ground lead pin 3-1-2b of the high-frequency line substrate 3-1.

In this manner, the high-frequency line substrate 3-1 on which the DC block capacitor 3-1-10 is mounted can be mounted on the printed circuit board 3-2, whereby the DC block capacitor 3-1-

10 can be inserted in series into the grounded coplanar lines 3-2-7.

[0075] In the present embodiment, as shown in Fig. 15, the shapes of the ground lead pins 3-1-2a and 3-1-2b and of the signal lead pins 3-1-3a and 3-1-3b are determined in such a manner that the height of the ground lead pins 3-1-2a and 3-1-2b from the upper surface of the printed circuit board 3-2 is greater than that of the signal lead pins 3-1-3a and 3-1-3b at the contact portions between the signal lead pins 3-1-3a and 3-1-3b and the signal lines 3-2-3a and 3-2-3b, and the contact portions between the ground lead pins 3-1-2a and 3-1-2b and the ground planes 3-2-2a and 3-2-2b.

[0076] As is clear from Fig. 15, needless to say, the height of upper surfaces of the signal lead pins 3-1-3a and 3-1-3b at the connection portions between the signal lead pins 3-1-3a and 3-1-3b and the signal lines 3-1-6a and 3-1-6b is the same as the height of the upper surfaces of the ground lead pins 3-1-2a and 3-1-2b at the connection portions between the ground lead pins 3-1-2a and 3-1-2b and the ground planes 3-1-5. The signal lead pins 3-1-3a and 3-1-3b are shaped such that the upper surfaces thereof become lower in height from the high-frequency line substrate 3-1 toward the signal lines 3-2-3a and 3-2-3b.

[0077] A high-frequency signal propagates from the printed circuit board 3-2 to the high-frequency line substrate 3-1 through the signal lead pin 3-1-3a. Furthermore, a high-frequency signal propagates from the high-frequency line substrate 3-1 to the printed circuit board 3-2 through the signal lead pin 3-1-3b. In such a case, since the signal lead pins 3-1-3a and 3-1-3b are exposed to the air, the capacitance between the signal lead pins 3-1-3a and 3-1-3b and the ground lead pins 3-1-2a and 3-1-2b decreases, and the characteristic impedance of the coplanar line tends to increase.

[0078] In the present embodiment, at the contact portions between the signal lead pins 3-1-3a and 3-1-3b and the signal lines 3-2-3a and 3-2-3b, and the contact portions between the ground lead pins 3-1-2a and 3-1-2b and the ground planes 3-2-2a and 3-2-2b, the height of the ground lead pins 3-1-2a and 3-1-2b is made greater than that of the signal lead pins 3-1-3a and 3-1-3b. Thus, a structure is obtained in which the signal lead pins 3-1-3a and 3-1-3b are surrounded by the ground lead pins 3-1-2a and 3-1-2b that each function as the ground of the coplanar line.

[0079] With this structure, in the present embodiment, not only is it possible to prevent a decrease in capacitance between the signal lead pins 3-1-3a and 3-1-3b and the ground lead pins 3-1-2a and 3-1-2b, but also an increase in the characteristic impedance of the coplanar lines can be suppressed. As a result, impedance matching can be achieved between the grounded coplanar line 3-2-7 of the printed circuit board 3-2 and the grounded coplanar lines 3-1-11 and 3-1-12 of the high-frequency line substrate 3-1.

[0080] In addition, in the present embodiment, the ground lead pins 3-1-2a and 3-1-2b can enclose a line of electric force from the signal lead pins 3-1-3a and 3-1-3b so as not to leak the line of electric force to the adjacent signal lead pins 3-1-3a and 3-1-3b. As a result, crosstalk between the signal lead pins 3-1-3a and

3-1-3b and the adjacent signal lead pins 3-1-3a and 3-1-3b can be reduced.

[0081] Fig. 16 is a diagram illustrating simulation results of reflection loss characteristics and passage loss characteristics of the grounded coplanar line in the high-frequency line connecting structure of the present embodiment, and Fig. 17 is a diagram showing simulation results of crosstalk characteristics between adjacent channels and passage loss characteristics of the grounded coplanar line in the high-frequency line connecting structure of the present embodiment.

[0082] Reference numeral 600 in Figs. 16 and 17 indicates the reflection loss characteristics, and reference numeral 601 indicates the passage loss characteristics. Reference numeral 602 of Fig. 17 indicates a crosstalk between adjacent channels occurring when the shape of the ground lead pins 3-1-2a and 3-1-2b is identical to that of the signal lead pins 3-1-3a and 3-1-3b, and reference numeral 603 indicates a crosstalk between adjacent channels in the present embodiment.

[0083] In the present embodiment, by mounting the high-frequency line substrate 3-1 onto the printed circuit board 3-2, the DC block capacitor 3-1-10 is inserted in series into the grounded coplanar line 3-2-7. Also in the present embodiment, by making the ground lead pins 3-1-2a and 3-1-2b at the connection portion with the printed circuit board 3-2 higher than the signal lead pins 3-1-3a and 3-1-3b, impedance matching can be achieved between the grounded coplanar line 3-2-7 of the printed circuit board 3-2 and the grounded coplanar lines 3-1-11 and 3-1-12 of the high-frequency line substrate 3-1.

[0084] As a result, in the present embodiment, the high-frequency line connecting structure capable of achieving favorable effects as shown in Figs. 16 and 17 and realizing low reflection loss characteristics, low passage loss characteristics, and low crosstalk characteristics in a wide bandwidth, can be obtained.

[0085] Note that, in the present embodiment, the DC block capacitor is described as an example of the electronic component to be inserted in series into the coplanar line, but an electronic component other than the DC block capacitor may be used.

[0086] In the first and second embodiments, the dielectric 2-1-1, 2-1-7, 2-2-5, 3-1-1, and 3-2-5 constituting the grounded coplanar lines 2-1-9, 2-2-7, 3-1-11, 3-1-12, and 3-2-7 are low-loss ceramics such as alumina, but needless to say, liquid crystal polymer, polymide, quartz glass, or the like can be used instead.

[0087] Also, in the first and second embodiments, when mounting the high-frequency line substrates 2-1 and 3-1 on the printed circuit boards 2-2 and 3-2, the connection portions between the signal lead pins 2-1-3a, 2-1-3b, 3-1-3a, and 3-1-3b and the signal lines 2-2-3a, 2-2-3b, 3-2-3a, and 3-2-3b, the connection portions between the ground lead pins 2-1-2a, 2-1-2b, 3-1-2a, and 3-1-2b and the ground planes 2-2-2a, 2-2-2b, 3-2-2a, and 3-2-2b, the connection portions between the signal lead pins 2-1-3a, 2-1-3b, 3-1-3a, and 3-1-3b and the signal lines 2-1-6, 3-1-6a, and 3-1-6b, and the connection portions between the ground lead pins 2-1-2a, 2-1-2b, 3-1-2a, and 3-1-2b and the ground planes 2-1-5 and 3-1-5 are typically gold-plated for the purpose of improving solder wettability. However, gold plating is not specified in particular because it is not the essence of the present invention.

Industrial Applicability

[0088] The present invention can be applied to a technique for three-dimensionally crossing high-frequency lines of a printed circuit board and inserting electronic components into the high-frequency lines of the printed circuit board.

Reference Signs List

[0089] 2-1, 3-1 High-frequency line substrate

2-1-1, 2-2-5, 3-1-1, 3-2-5 Dielectric

2-1-2a, 2-1-2b, 3-1-2a, 3-1-2b Ground lead pin

2-1-3a, 2-1-3b, 3-1-3a, 3-1-3b Signal lead pin

2-1-4, 2-1-5, 2-2-2a, 2-2-2b, 2-2-4, 3-1-4, 3-1-5, 3-2-2a, 3-2-2b Ground plane

2-1-6, 2-2-3a, 2-2-3b, 3-1-6a, 3-1-6b, 3-1-7a, 3-1-7b, 3-2-3a, 3-2-3b Signal line

2-1-7 Dielectric

2-1-8, 2-2-6, 3-2-6, 3-1-8 Ground via

2-1-9, 2-2-7, 3-1-11, 3-1-12, 3-2-7 Grounded coplanar line

2-2, 3-2 Printed circuit board

2-2-1 Microstrip line

3-1-9a, 3-1-9b Via

3-1-10 DC block capacitor

3-1-13a, 3-1-13b Pseudo-coaxial line structure

Claims

1. A high-frequency line connecting structure, comprising a first substrate and a second substrate mounted on the first substrate,

the first substrate including a first high-frequency line,

the second substrate including a second high-frequency line and a lead pin made of a conductor that electrically connects the first high-frequency line and the second high-frequency line,

the first high-frequency line including

a first signal line formed on a first main surface of the first substrate and having a section where being divided into two in the middle, and

a first ground formed on the first main surface of the first substrate along the first signal line and having a section where being divided into two, the section being at the same position in an extension direction as the section where the first signal line is divided,

the second high-frequency line including

a second signal line formed on a first main surface of the second substrate facing the first substrate so that an extension direction is parallel to the extension direction of the first signal line, and

a second ground formed on the first main surface of the second substrate along the second signal line so that the extension direction is parallel to the extension direction of the first ground,

the lead pin being composed of

signal lead pins that are connected to both ends of the second signal line respectively so as to be in contact with one part of the first signal line and another part of the first signal line that are divided, in a state in which the second substrate is mounted on the first substrate in such a manner that the second signal line is positioned on the divided section of the first signal line and the second ground is positioned on the divided section of the first ground, and

ground lead pins that are connected to both ends of the second ground respectively so as to be in contact with one part of the first ground and another part of the first ground that are divided, in a state in which the second substrate is mounted on the first substrate,

wherein a height of the ground lead pin from the first main surface of the first substrate is greater than that of the signal lead pin at a contact portion between the signal lead pin and the first signal line and a contact portion between the ground lead pin and the first ground.

2. The high-frequency line connecting structure according to claim 1, wherein

the second substrate further includes:

a third high-frequency line formed on a second main surface of the second substrate that is on a side opposite to the first main surface; and

an electronic component mounted on the second main surface of the second substrate and inserted in series into the third high-frequency line,

the third high-frequency line includes:

a third signal line formed on the second main surface of the second substrate and having a section divided into two in the middle; and

a third ground formed on the second main surface of the second substrate so as to surround the third signal line,

the electronic component has two electrodes connected to one part of the third signal line and another part of the third signal line that are divided,

the second signal line of the second high-frequency line includes a section divided into two in the middle,

the second ground of the second high-frequency line is formed so as to surround the second signal line, and

both ends of the third signal line are connected to one part of the second signal line and another part of the second signal line that are divided, via vias formed on the second substrate.

3. The high-frequency line connecting structure according to claim 1, wherein

a plurality of the first signal lines of the first high-frequency line are arranged in parallel, a plurality of the first grounds of the first high-frequency line are arranged on both sides of the first signal lines along the first signal lines,

a plurality of the second signal lines of the second high-frequency line are arranged in parallel,

a plurality of the second grounds of the second high-frequency line are arranged on both sides of the second signal lines along the second signal lines,

a plurality of the signal lead pins are arranged in parallel along an alignment direction of the first signal lines and the second signal lines, and

a plurality of the ground lead pins are arranged in parallel along an alignment direction of the first grounds and the second grounds.

4. The high-frequency line connecting structure according to claim 2, wherein

a plurality of the first signal lines of the first high-frequency line are arranged in parallel,

a plurality of the first grounds of the first high-frequency line are arranged on both sides of the first signal lines along the first signal lines,

a plurality of the second signal lines of the second high-frequency line are arranged in parallel,

a plurality of the second grounds of the second high-frequency line are arranged so as to surround the plurality of second signal lines, a plurality of the third signal lines of the third high-frequency line are arranged in parallel,

the third ground of the third high-frequency line is arranged so as to surround a plurality of the third signal lines,

the electronic component is provided for each of the third signal lines,

a plurality of the signal lead pins are arranged in parallel along an alignment direction of the first signal lines, the second signal lines, and the third signal lines, and

a plurality of the ground lead pins are arranged in parallel along an alignment direction of the first grounds and the second grounds.

5. The high-frequency line connecting structure according to claim 2 or 4, wherein the electronic component is a DC block capacitor.

Fig. 1

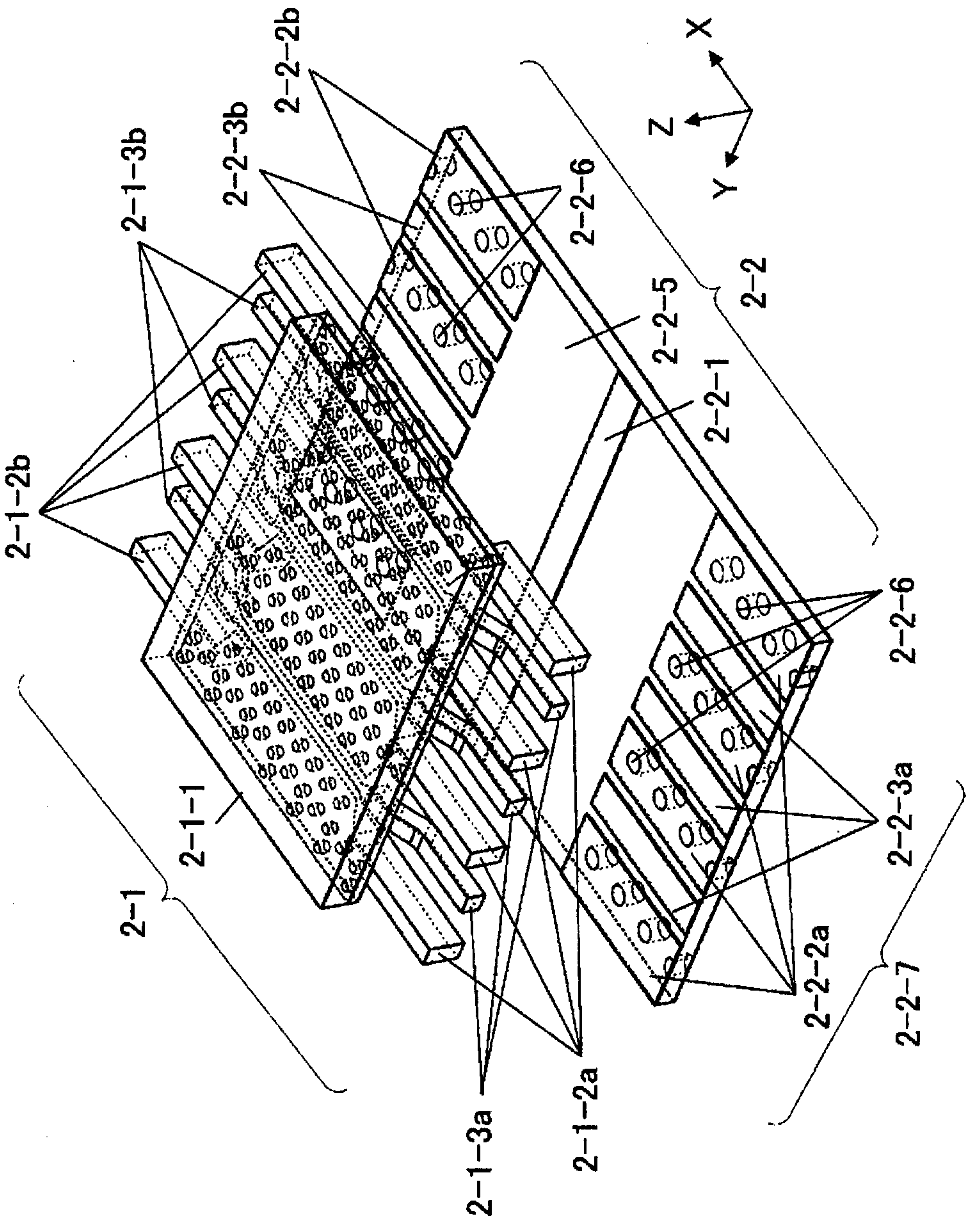

2-1-2b
2-1-3b
2-2-3b
2-2-2b
2-2-6
Z
X
Y
2-2-5
2-2-1
2-2
2-1-1
2-1
2-2-6
2-2-3a
2-2-2a
2-2-7
2-1-3a
2-1-2a

Fig. 2

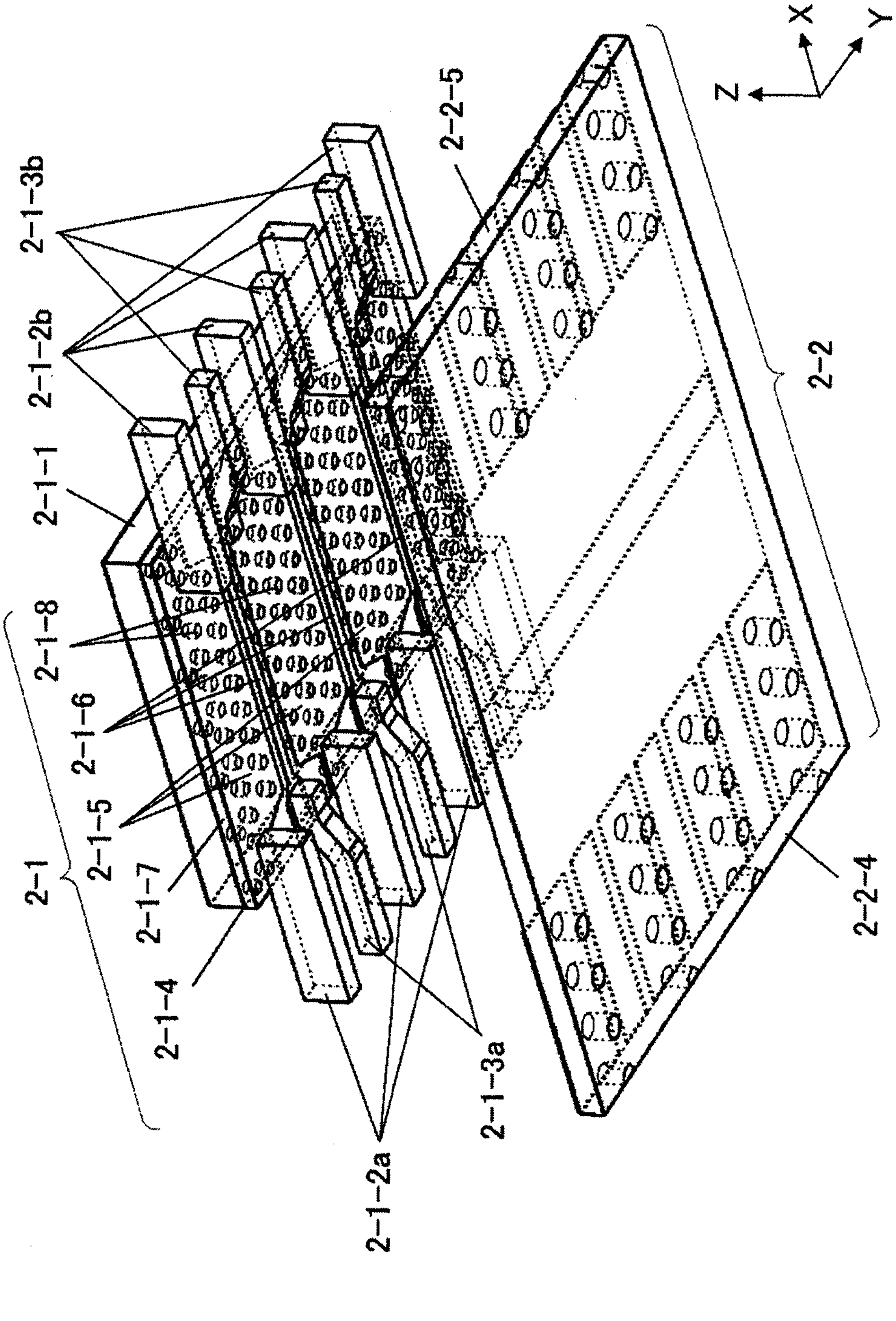


Fig. 3

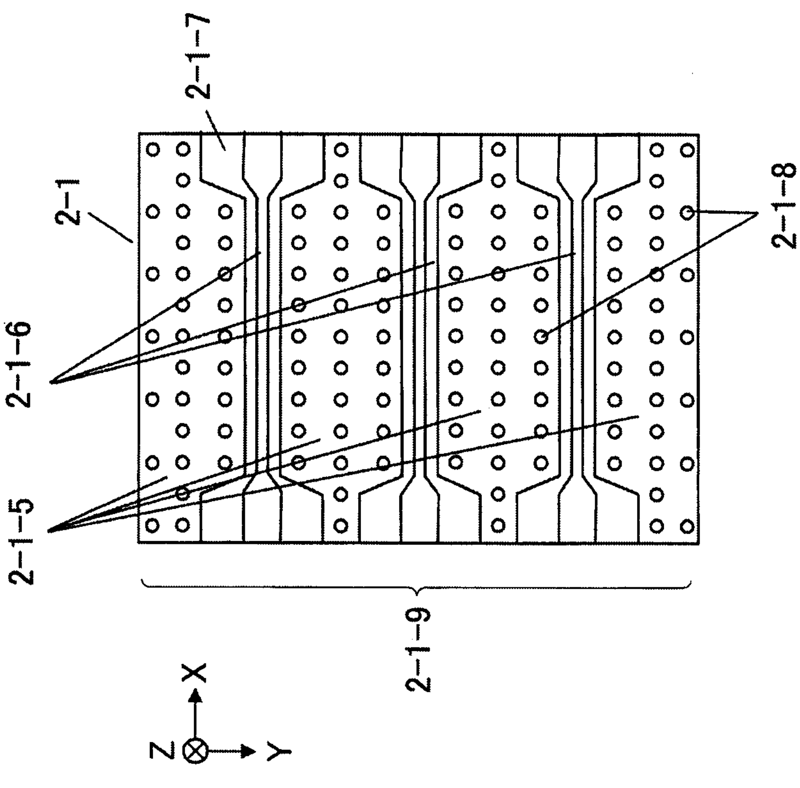
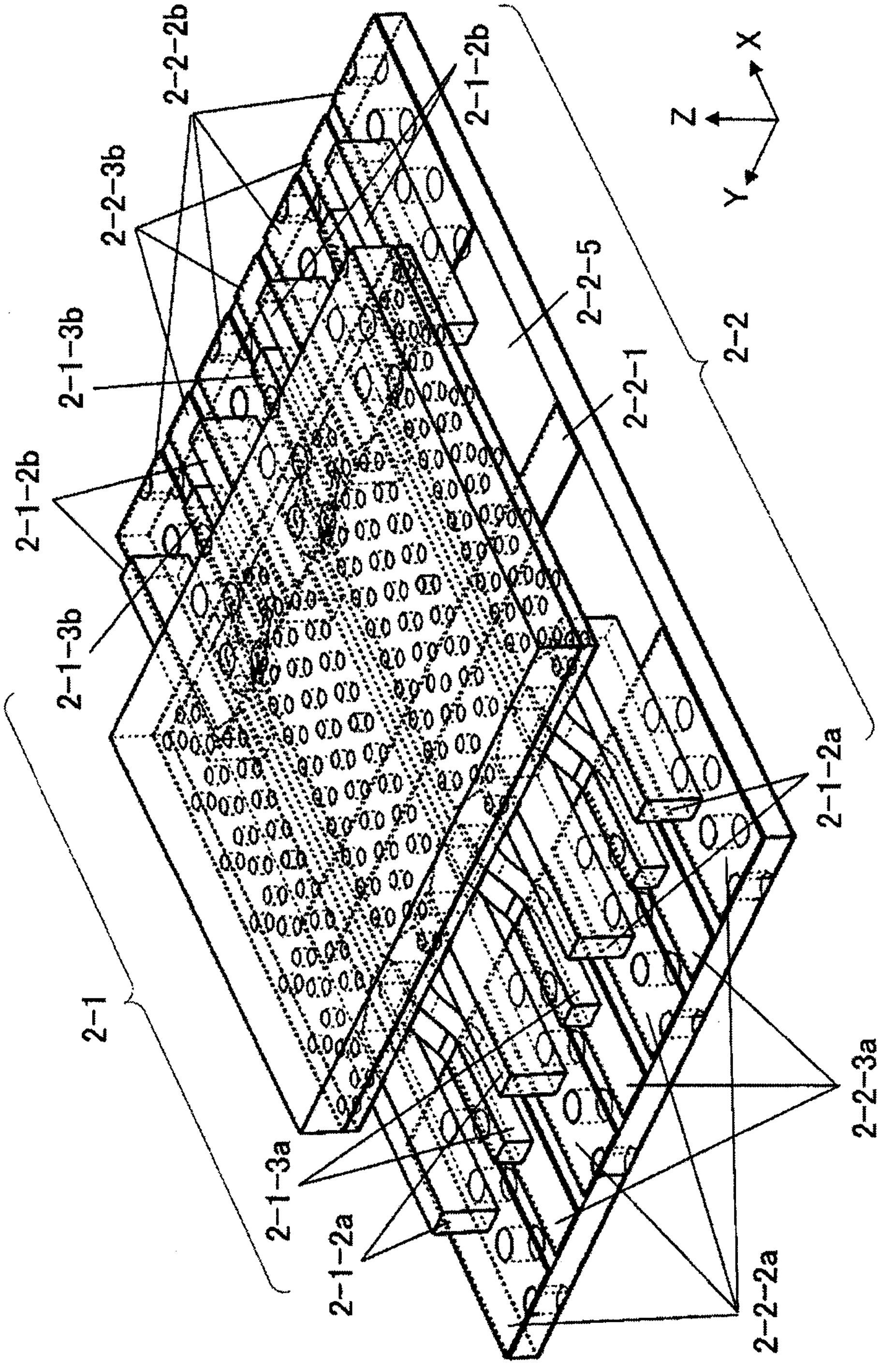


Fig. 4



2-1
2-2
2-1-3b
2-1-2b
2-1-3b
2-2-3b
2-2-2b
2-1-2b
2-2-5
2-2-1
2-1-2a
2-2-3a
2-2-2a
2-1-3a
2-1-2a
Z
X
Y

Fig. 5

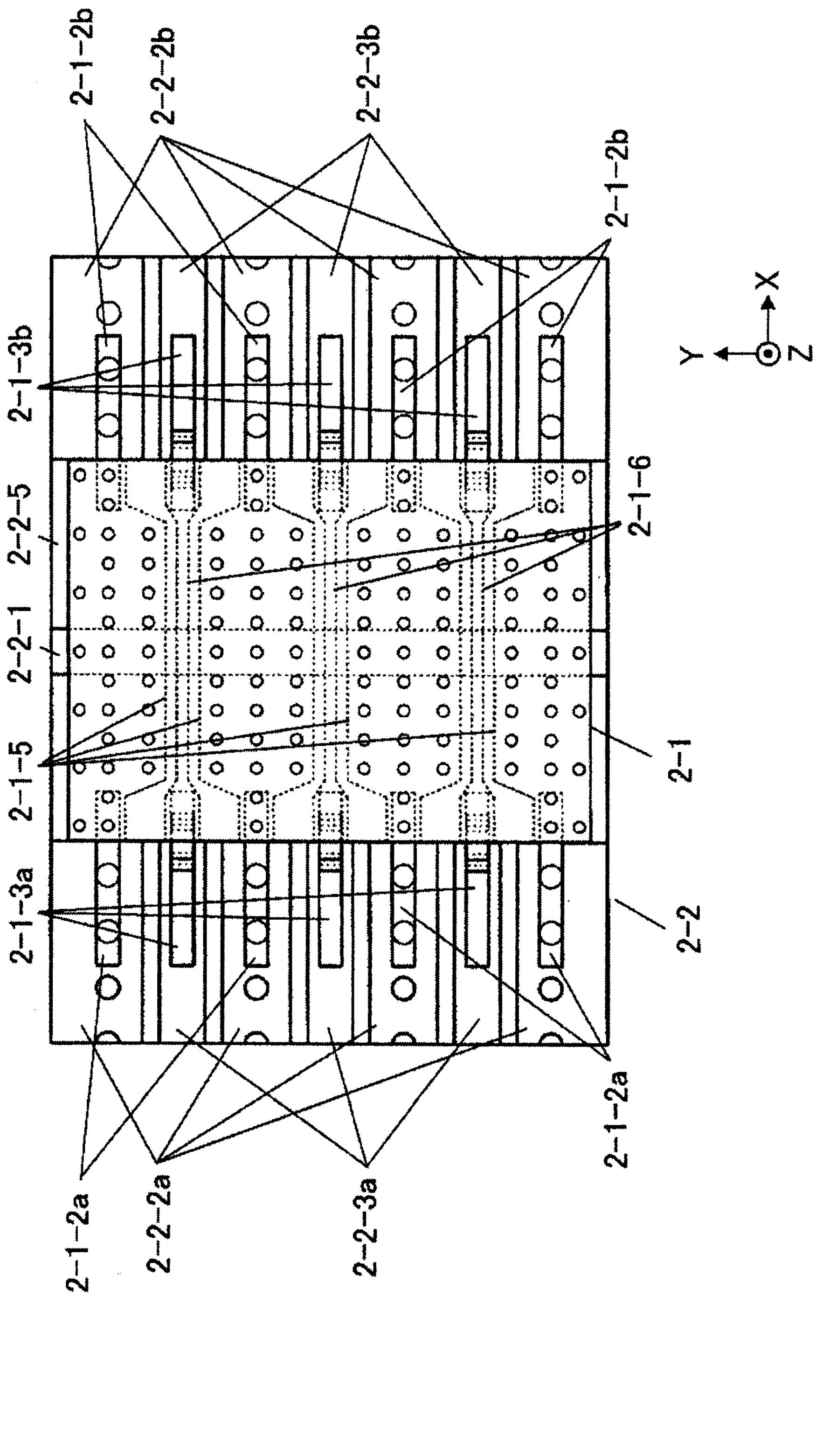

2-1-2b
2-2-2b
2-2-3b
2-1-2b
2-1-3b
2-2-5
2-2-1
2-1-5
2-1-3a
2-1-6
2-1
2-2
2-1-2a
2-2-2a
2-2-3a
2-1-2a
Y
X
Z

Fig. 6

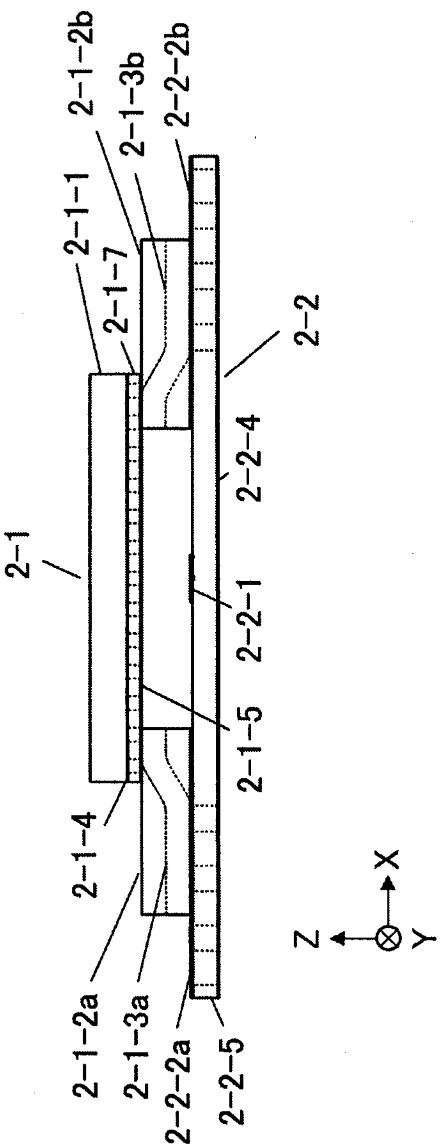
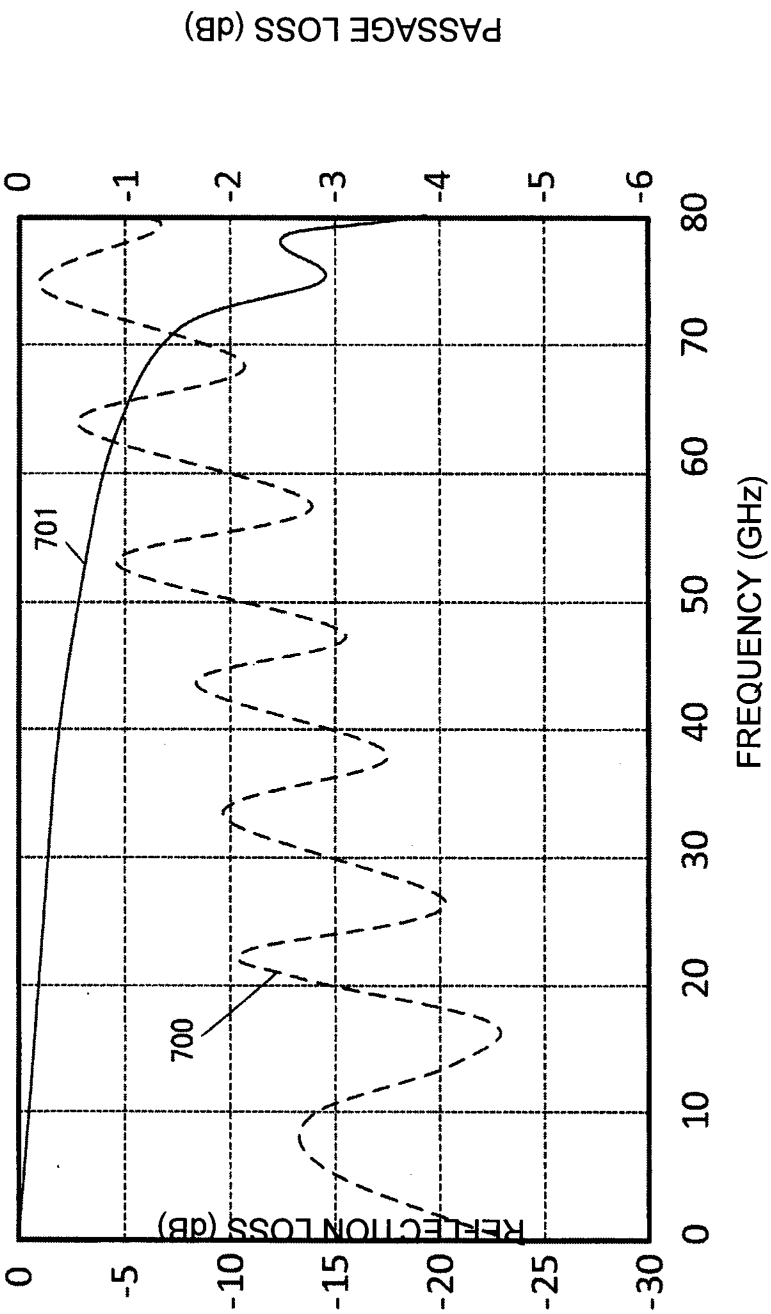

2-1
2-1-1
2-1-7
2-1-2b
2-1-3b
2-2-2b
2-2
2-2-4
2-2-1
2-1-5
2-1-4
2-1-2a
2-1-3a
2-2-2a
2-2-5
Z
X
Y

Fig. 7


PASSAGE LOSS (dB)
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-1
-2
-3
-4
-5
-6
REFLECTION LOSS (dB)
0
-5
-10
-15
-20
-25
-30
FREQUENCY (GHz)
0
10
20
30
40
50
60
70
80
700
701

Fig. 8

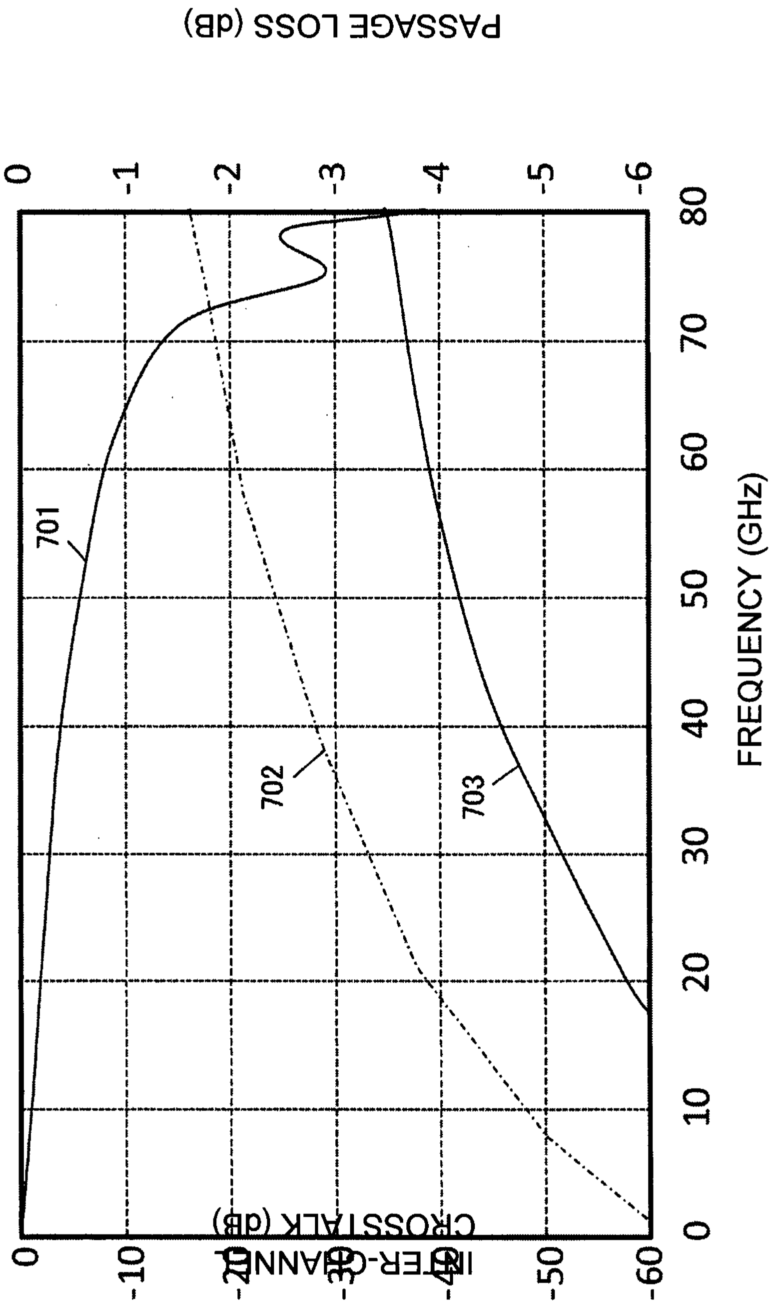

PASSAGE LOSS (dB)
0
-1
-2
-3
-4
-5
-6
INTER-CHANNEL CROSSTALK (dB)
0
-10
-20
-30
-40
-50
-60
FREQUENCY (GHz)
0
10
20
30
40
50
60
70
80
701
702
703

Fig. 9

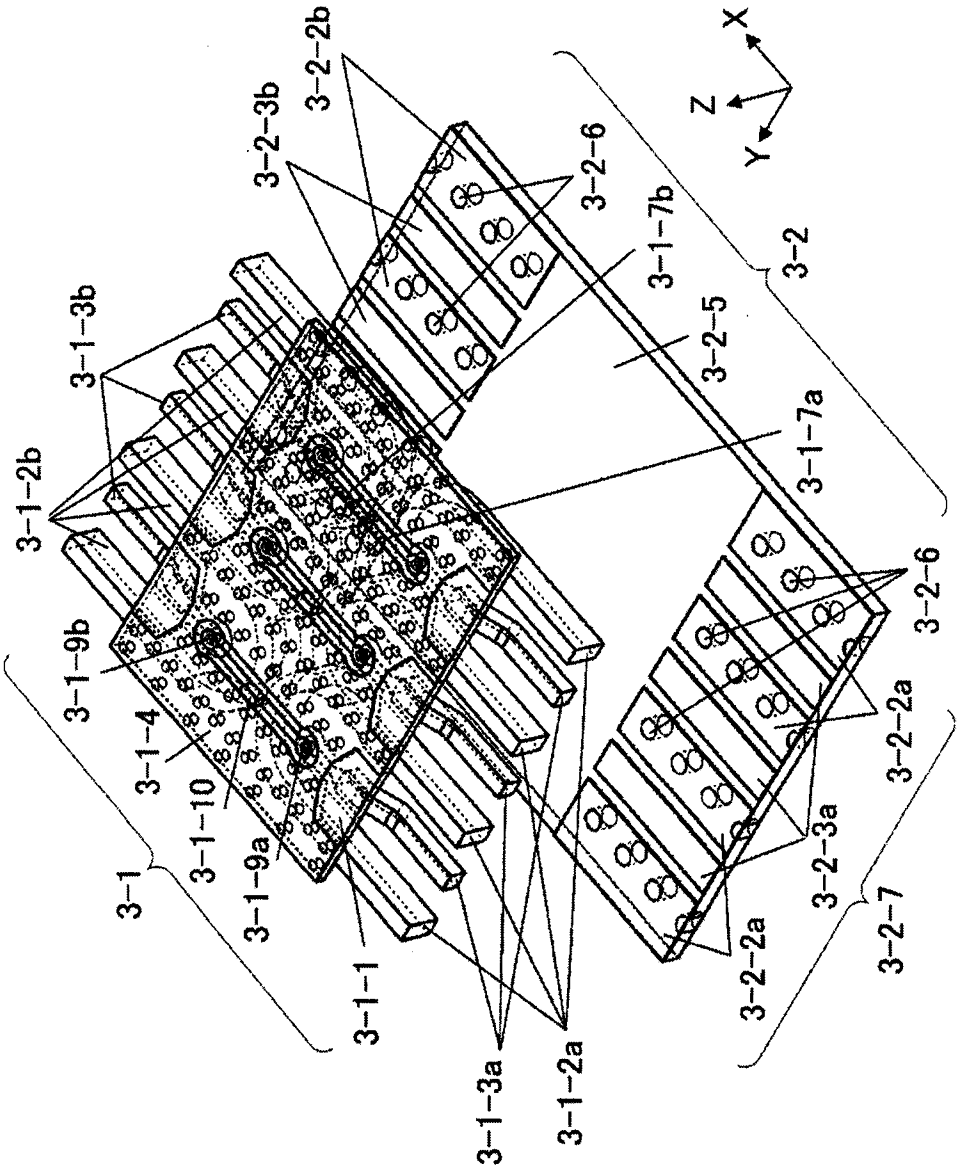

3-1
3-1-1
3-1-2a
3-1-2b
3-1-3a
3-1-3b
3-1-4
3-1-7a
3-1-7b
3-1-9a
3-1-9b
3-1-10
3-2
3-2-2a
3-2-2b
3-2-3a
3-2-3b
3-2-5
3-2-6
3-2-7
X
Y
Z

Fig. 10

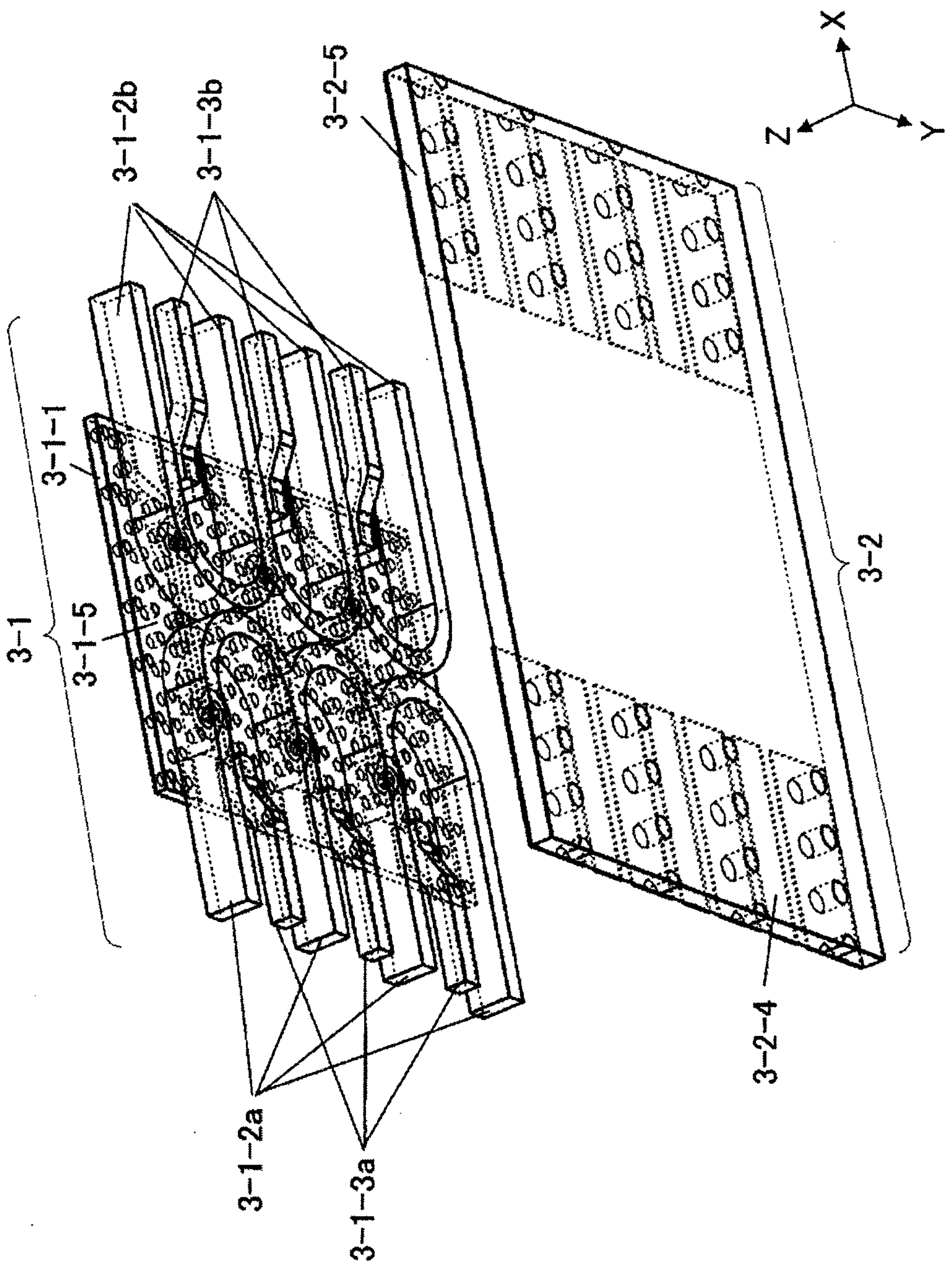


Fig. 11

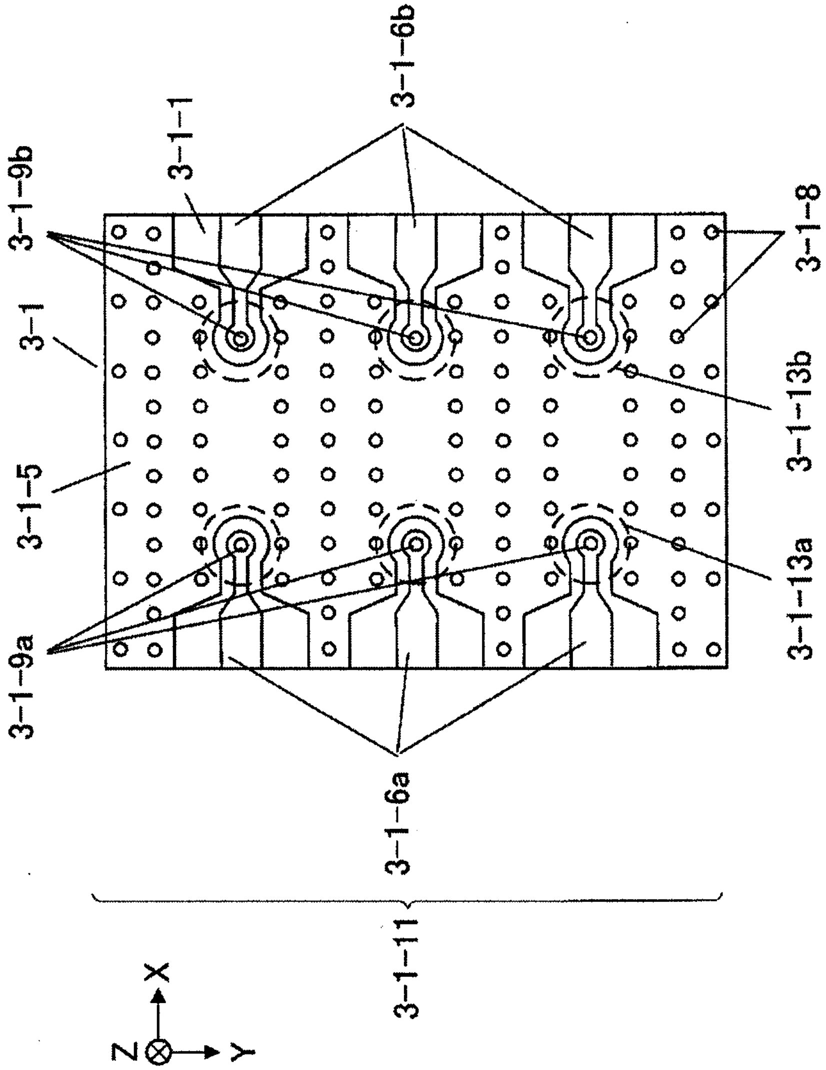


Fig. 12

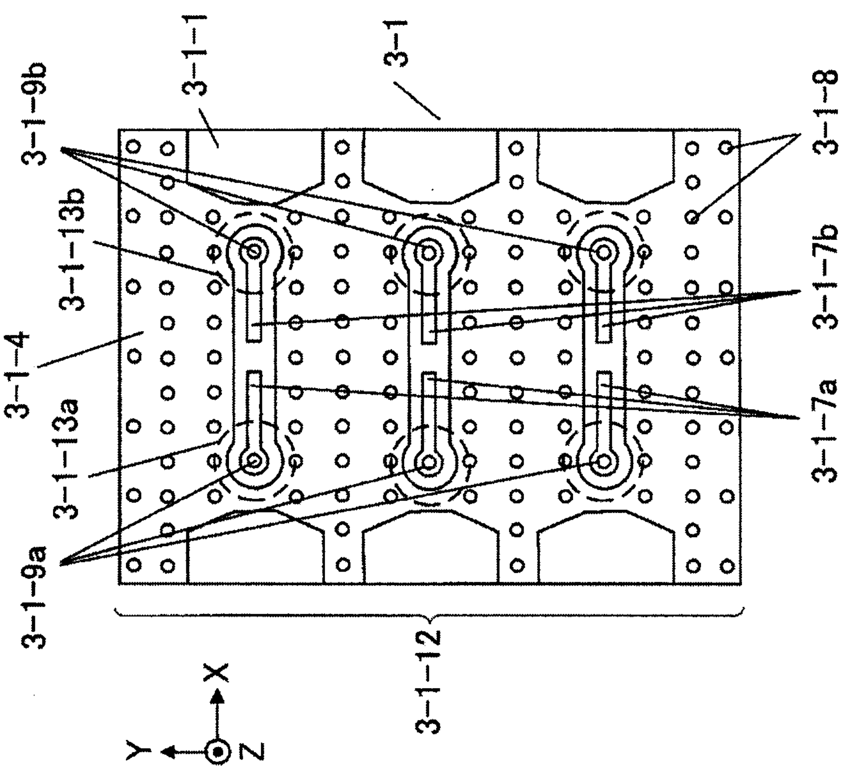


Fig. 13

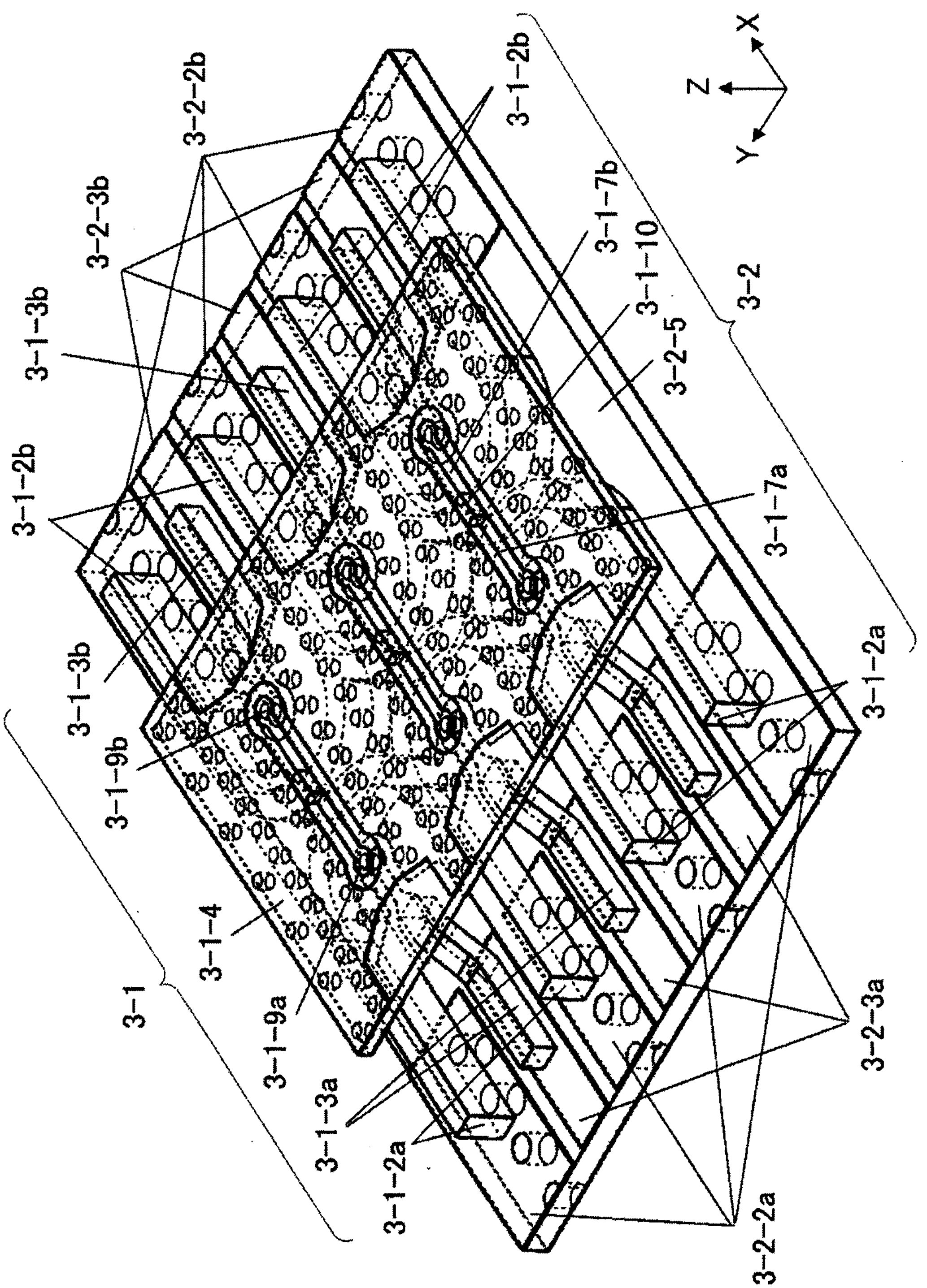

3-2-2b
3-2-3b
3-1-3b
3-1-2b
3-1-3b
3-1-9b
3-1-4
3-1
3-1-9a
3-1-3a
3-1-2a
3-1-2b
3-1-7b
3-1-10
3-2-5
3-2
3-1-7a
3-1-2a
3-2-3a
3-2-2a
Z
X
Y

Fig. 14

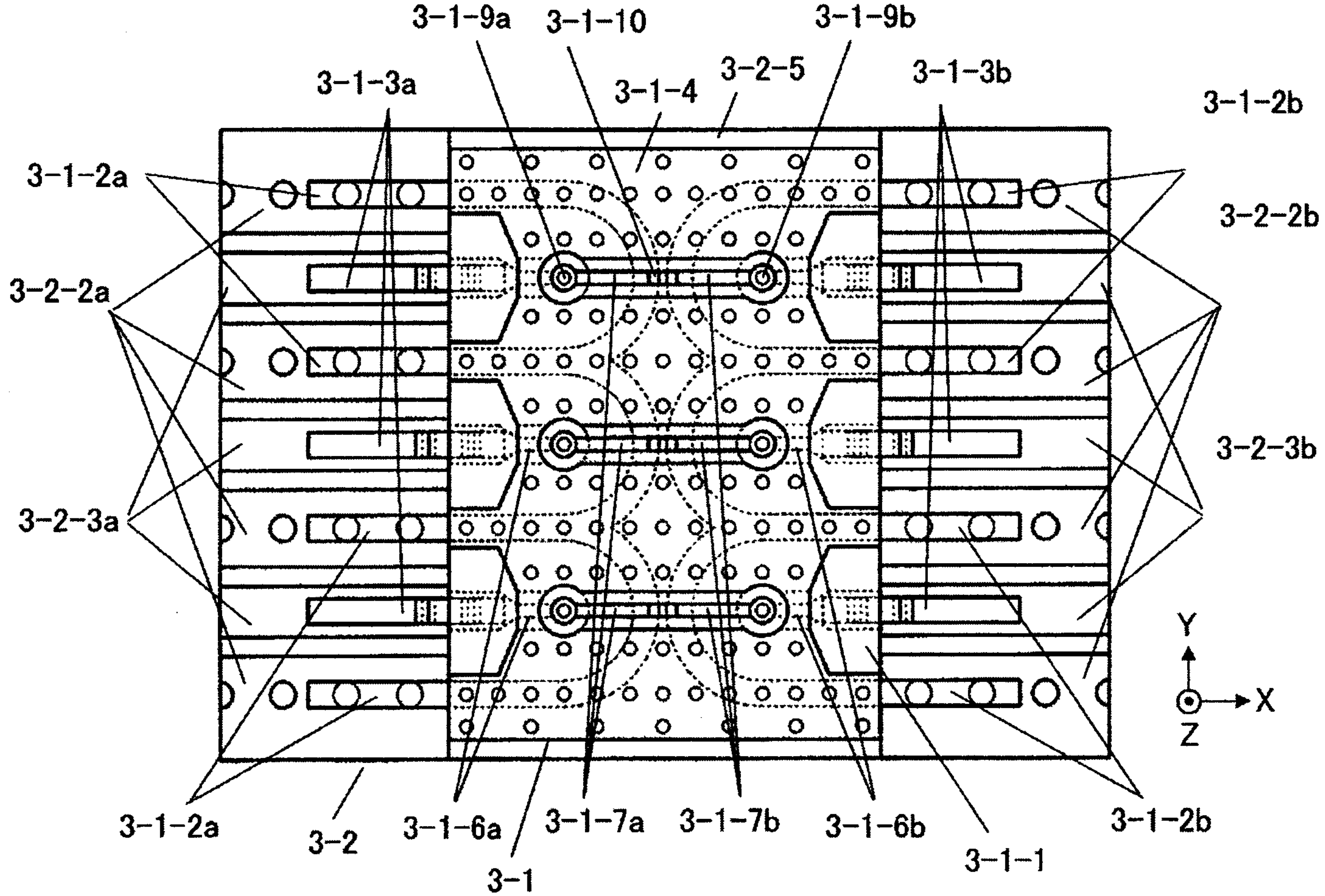

3-1-9a
3-1-10
3-1-9b
3-1-3a
3-1-4
3-2-5
3-1-3b
3-1-2b
3-1-2a
3-2-2b
3-2-2a
3-2-3b
3-2-3a
Y
X
Z
3-1-2a
3-2
3-1-6a
3-1-7a
3-1-7b
3-1-6b
3-1-2b
3-1-1
3-1

Fig. 15

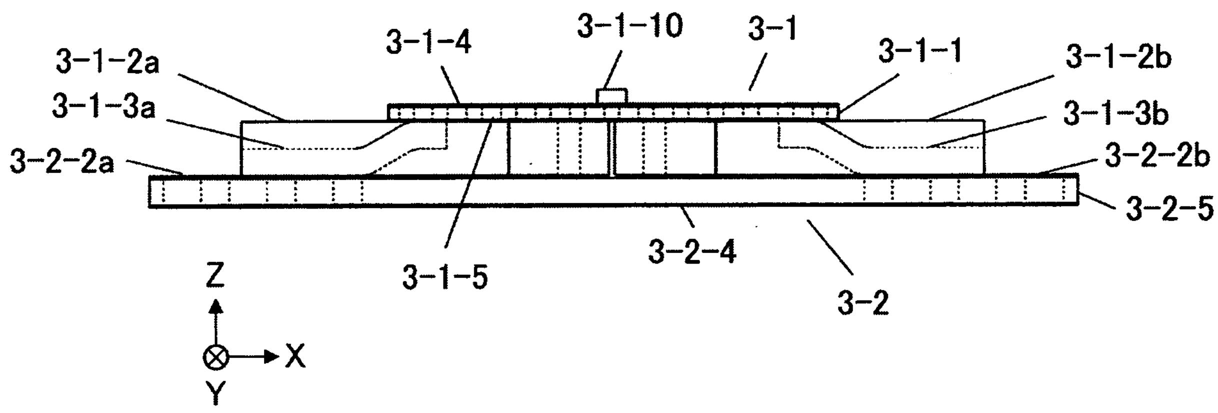

3-1-2a
3-1-3a
3-2-2a
3-1-4
3-1-10
3-1
3-1-1
3-1-2b
3-1-3b
3-2-2b
3-2-5
3-1-5
3-2-4
3-2
Z
X
Y

Fig. 16

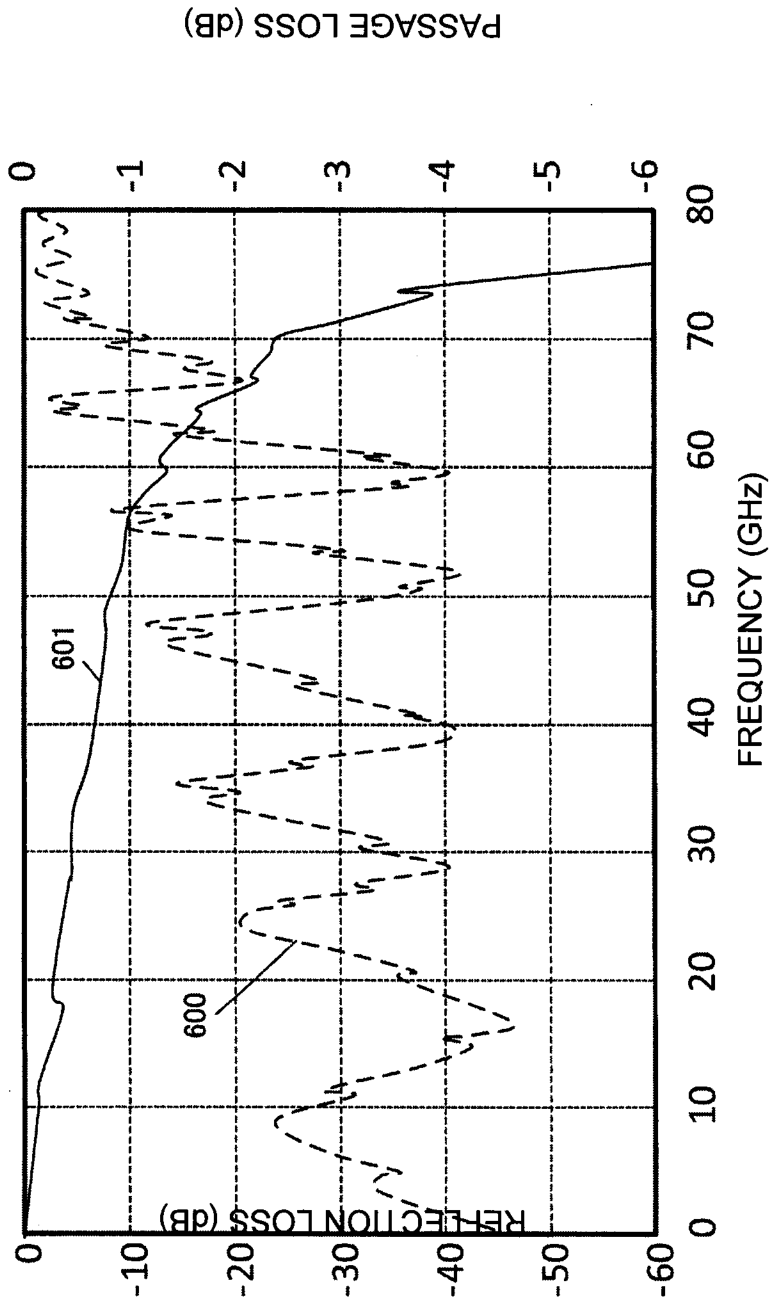

PASSAGE LOSS (dB)
0
-1
-2
-3
-4
-5
-6
REFLECTION LOSS (dB)
0
-10
-20
-30
-40
-50
-60
601
600
0
10
20
30
40
50
60
70
80
FREQUENCY (GHz)

Fig. 17

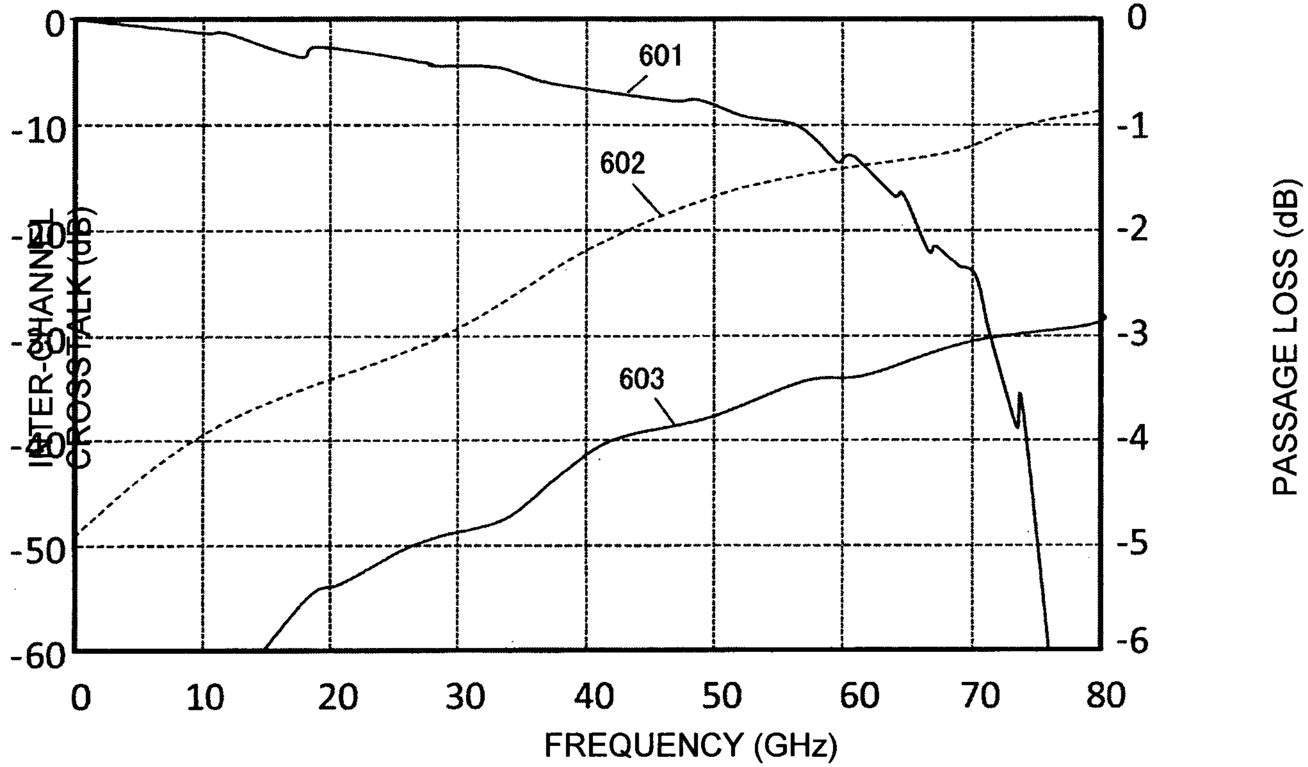

601
602
603
INTER-CHANNEL CROSSTALK (dB)
PASSAGE LOSS (dB)
FREQUENCY (GHz)
0
-10
-20
-30
-40
-50
-60
0
-1
-2
-3
-4
-5
-6
0
10
20
30
40
50
60
70
80

Fig. 18A

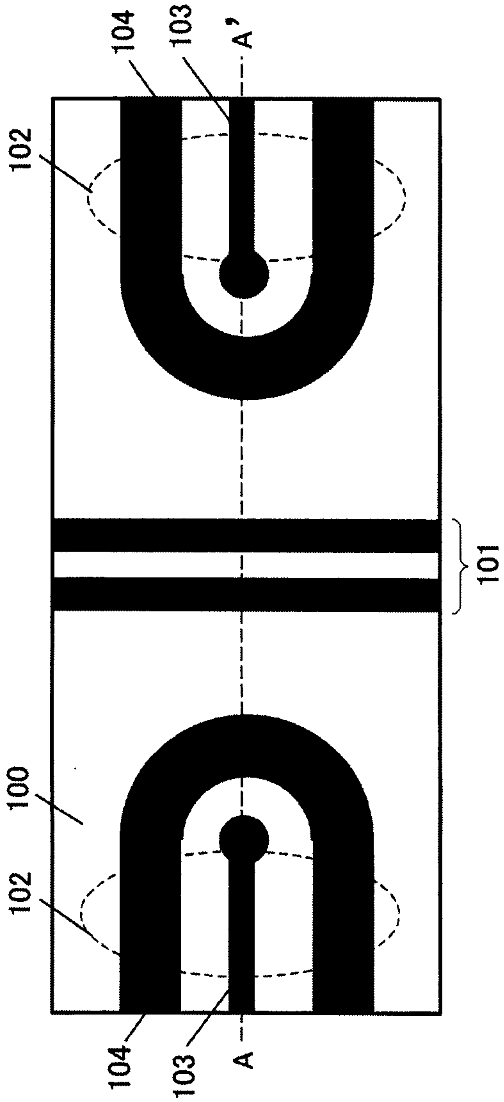


Fig. 18B

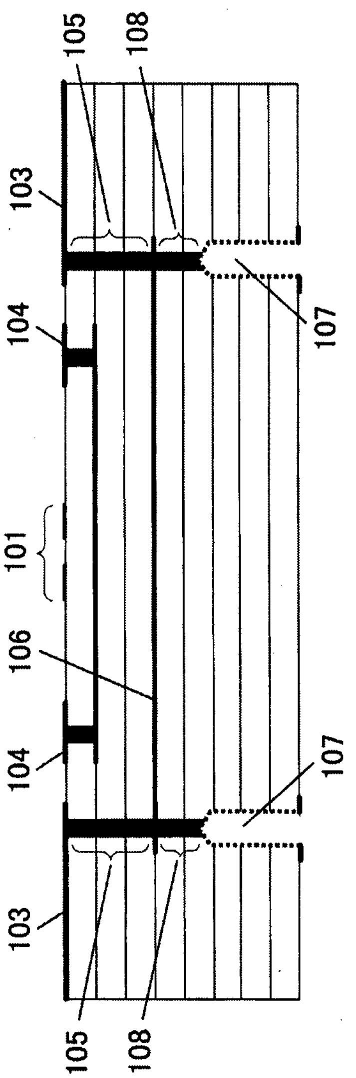
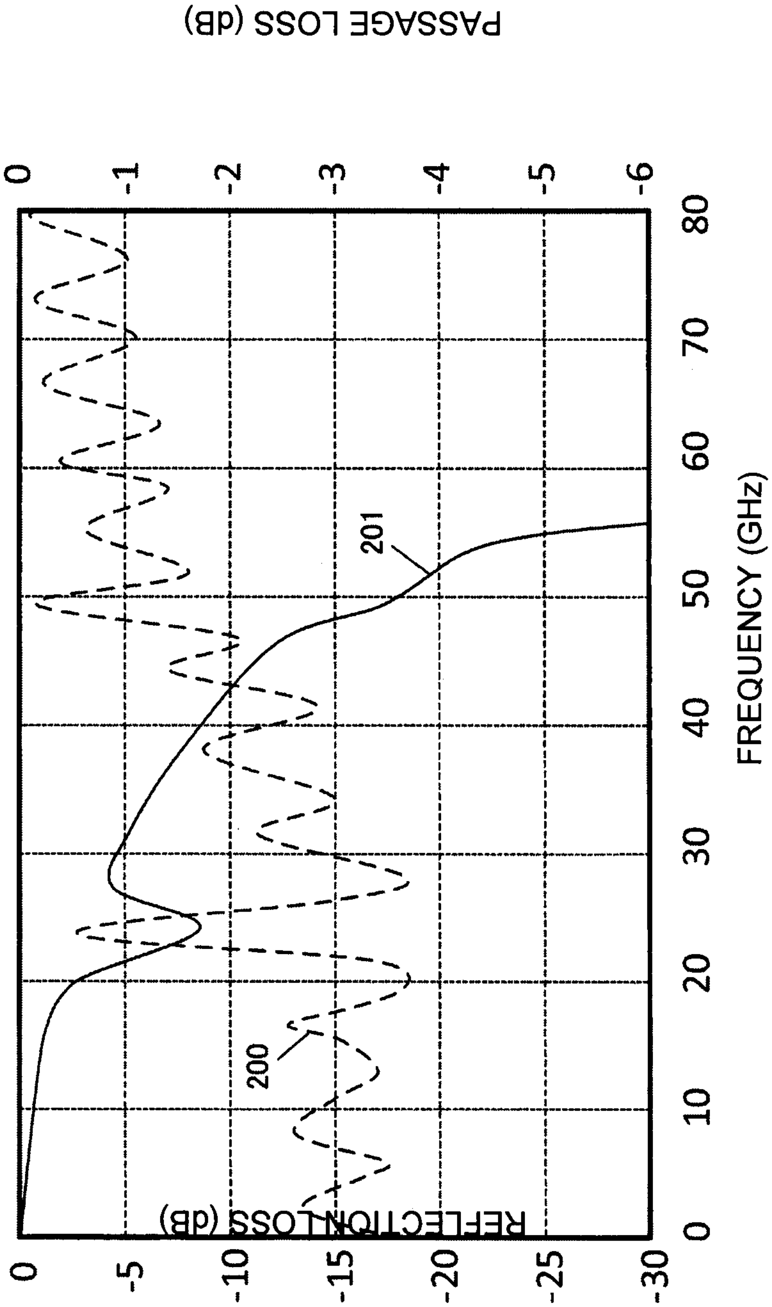


Fig. 19


PASSAGE LOSS (dB)
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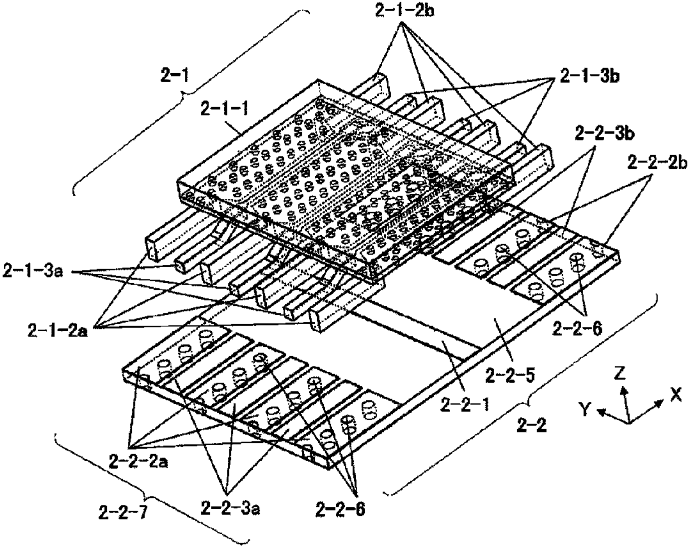
-1
-2
-3
-4
-5
-6
REFLECTION LOSS (dB)
0
-5
-10
-15
-20
-25
-30
200
201
0
10
20
30
40
50
60
70
80
FREQUENCY (GHz)


2-1-2b
2-1
2-1-3b
2-1-1
2-2-3b
2-2-2b
2-1-3a
2-2-6
2-1-2a
2-2-5
Z
X
Y
2-2-1
2-2
2-2-2a
2-2-7
2-2-3a
2-2-6