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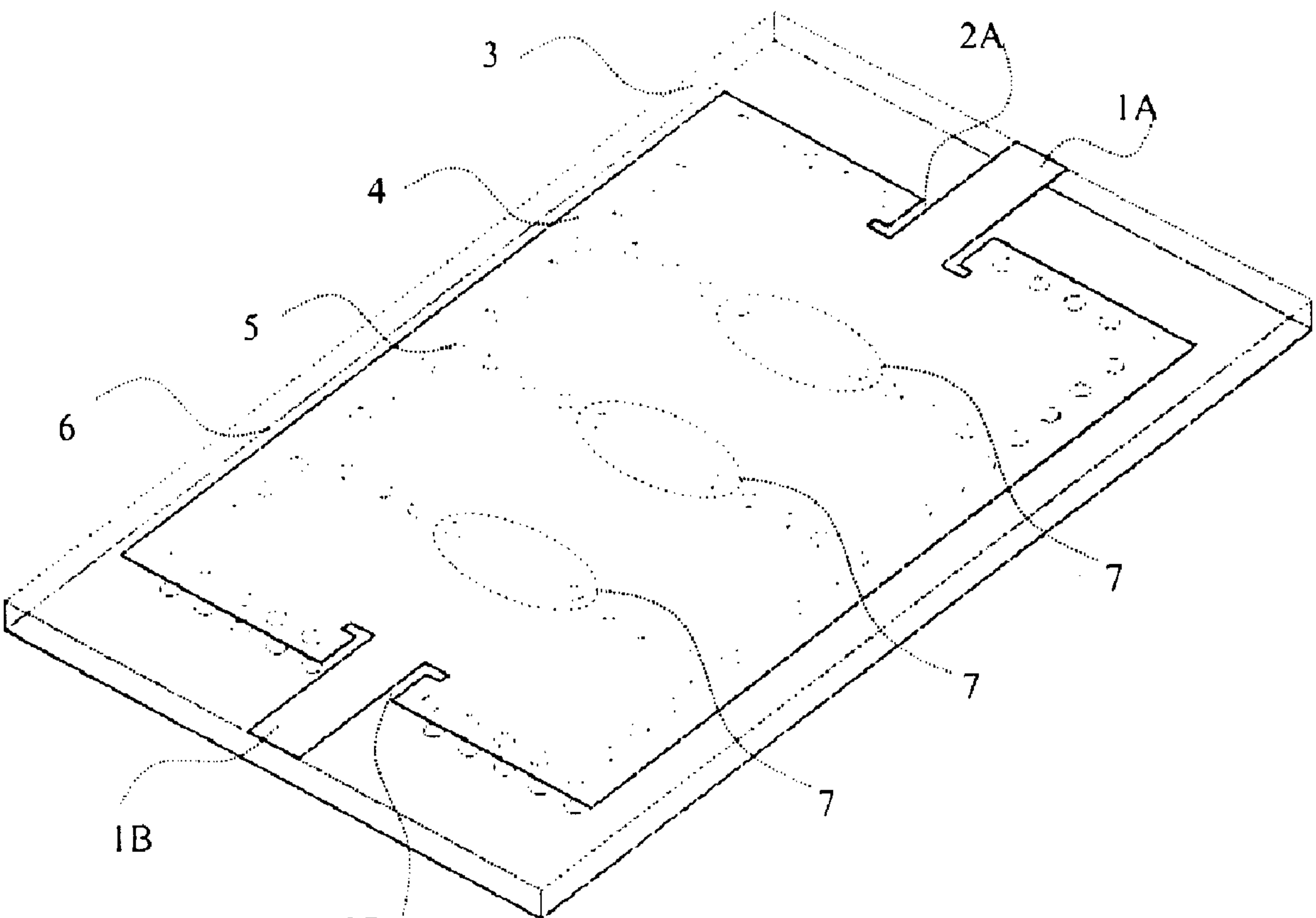
(54) Titre : FILTRE DE GUIDE D'ONDES AVEC LARGE BANDE AFFAIBLIE, REPOSANT SUR UN MECANISME DE SUBSTRAT DE GUIDE D'ONDES INTEGRE

(54) Title: WAVEGUIDE FILTER WITH BROAD STOPBAND BASED ON SUGSTRATE INTEGRATED WAVEGUIDE SCHEME



(57) Abrégé/Abstract:
A waveguide bandpass filter utilizing a substrate integrated waveguide (SIW) scheme is provided with wide stopband performance and low in-band insertion loss at microwave and millimetre-wave frequencies. The filter consists of cascaded oversized substrate

(57) Abrégé(suite)/Abstract(continued):
integrated waveguide cavities, and at least one transmission line of either microstrip, stripline or coplanar waveguide with coupling slots is used as the input/output. The transmission zeros generated by the non-physical cross-couplings through the higher-order modes in the oversized substrate integrated waveguide cavity are assigned to improve the stopband performance. This filter is very easy to integrate with planar circuits for microwave and millimetre-wave applications. Three typical implementations of this filter are illustrated on a general dielectric substrate using linear arrays of metallised via holes by a standard PCB process. These three typical implementations operate at a center frequency of 20.2 GHz, although other center frequencies, such as approximately 5 GHz to approximately 60 GHz, are achievable.

Patent:

Waveguide Filter with Broad Stopband Based on Substrate Integrated Waveguide Scheme

Inventors: Xiao-Ping Chen, Ke Wu, Dan Drolet

ABSTRACT— A waveguide bandpass filter utilizing a substrate integrated waveguide (SIW) scheme is provided with wide stopband performance and low in-band insertion loss at microwave and millimetre-wave frequencies. The filter consists of cascaded oversized substrate integrated waveguide cavities, and at least one transmission line of either microstrip, stripline or coplanar waveguide with coupling slots is used as the input/output. The transmission zeros generated by the non-physical cross-couplings through the higher-order modes in the oversized substrate integrated waveguide cavity are assigned to improve the stopband performance. This filter is very easy to integrate with planar circuits for microwave and millimetre-wave applications. Three typical implementations of this filter are illustrated on a general dielectric substrate using linear arrays of metallised via holes by a standard PCB process. These three typical implementations operate at a center frequency of 20.2 GHz, although other center frequencies, such as approximately 5 GHz to approximately 60 GHz, are achievable.

FIELD OF THE INVENTION

This invention relates to waveguide bandpass filters. More particularly, this invention discloses a low in-band insertion loss and wide stopband filter that operates at microwave and millimetre-wave frequencies and utilizes the substrate integrated waveguide scheme for the low-cost and high-performance integration with planar circuits.

BACKGROUND OF THE INVENTION

Filters, which should have compact size, low in-band insertion loss, high selectivity, and wide stopband, are fundamental circuit elements for frequency band selection in modern transceivers. For example, in a typical Ka-band satellite ground terminal front end, the receive filter with a passband of 19.2 – 21.2 GHz should combine both low insertion loss within its passband, as well as high out-of-band rejection (>50 dB) in the satellite transmit frequency band of 29.5 – 30 GHz.

Substrate integrated waveguide (SIW) filters offer a low-cost, low mass and compact size alternative to conventional waveguide filters, while maintaining high performance. Furthermore, this technology allows easy integration of planar circuits on a single substrate using a standard printed circuit board (PCB) or low-temperature co-fired ceramic (LTCC) process. This can reduce the interconnection loss between components, while reducing the size and weight of the system. Furthermore, substrate integrated waveguide filters can offer a significant improvement in passive intermodulation performance over conventional approaches in certain applications.

Although many techniques were developed to improve the stopband performance of conventional rectangular waveguide filters, these techniques often utilize the E-plane discontinuities which are difficult to realize for substrate integrated waveguide filters implemented on a single-layer substrate. The transmission zeros (TZs) in the insertion loss response of a microwave filter can be used to improve the selectivity and stopband attenuation. In general, the implementation of transmission zeros can be obtained using the well known "extracted pole" technique or by introducing couplings between nonadjacent resonators (cross-couplings). However, the TZ cannot be far away from the desired passband due to the limitation of the physical structure.

The invention is thus based on the problem of providing a substrate integrated waveguide filter with low loss and broad stopband for low-cost, high-performance integration with planar circuit processes.

SUMMARY OF THE INVENTION

By means of the concept of the invention, a substrate integrated waveguide filter with low loss and high out-of-band rejection is disclosed. The filter consists of oversized substrate integrated waveguide cavities, of which the first/last oversized substrate integrated waveguide cavity is directly excited by at least one transmission line of either microstrip, stripline or coplanar waveguide with coupling slots for the dispersion reduction of the input/output post-wall iris. The entire filter is implemented using linear arrays of metallised via holes on a general dielectric substrate by a standard PCB or other planar circuit process. The diameter of via holes and the pitch between two via holes are chosen to suppress the radiation loss. When signal flows from the input port to the output port, the desired passband is produced by the fundamental mode of oversized substrate integrated waveguide cavities. The finite transmission zeros far away from the passband for the high out-of-band rejection will be generated by non-physical cross-coupling due to the cancellation between the two signal paths provided by the higher-order mode and the fundamental mode in the corresponding substrate integrated waveguide cavities. The position of every finite transmission zero can be independently controlled for the different requirement on the out-of-band rejection by changing the couplings and the size of the corresponding oversized substrate integrated waveguide cavity.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention, reference is made to the accompanying drawings, which are incorporated herein by reference and in which:

FIG. 1 is a graphic illustration of an oversized TE_{101}/TE_{301} mode substrate integrated waveguide cavity excited by microstrip lines.

FIG. 2 is a schematic description of a 4^{th}-degree substrate integrated waveguide filter with four oversized TE_{101}/TE_{301} mode substrate integrated waveguide cavities.

FIG. 3 is a schematic description of a 4^{th}-degree substrate integrated waveguide filter with three oversized TE_{101}/TE_{301} mode substrate integrated waveguide cavities and one oversized TE_{101}/TE_{201} mode substrate integrated waveguide cavity.

FIG. 4 is a schematic description of a 4^{th}-degree substrate integrated waveguide filter with two oversized TE_{101}/TE_{301} mode substrate integrated waveguide cavities and two oversized TE_{101}/TE_{201} mode substrate integrated waveguide cavities.

FIG. 5 is a typical frequency response illustration of a K-band 4^{th}-degree substrate integrated waveguide filter with the same topology as that presented in FIG. 2 according to the invention.

FIG. 6 is a typical frequency response illustration of a K-band 4^{th}-degree substrate integrated waveguide filter with the same topology as that presented in FIG. 3 according to the invention.

FIG. 7 is a typical frequency response illustration of a K-band 4^{th}-degree substrate integrated waveguide filter with the same topology as that presented in FIG. 4 according to the invention.

DETAILED DESCRIPTION

The structure block diagrams and the graphic illustration of the proposed oversized substrate integrated waveguide cavity, which is symmetrically excited for the operation of the TE_{101}/TE_{301} mode, are shown in FIG. 1. The oversized substrate integrated waveguide cavity is formed by linear arrays of metallised via holes 5 on a general dielectric substrate 3 with top metal 4 and bottom metal 6 using a standard PCB or other planar circuit process. Two paths for signal flow are provided by the fundamental TE_{101} mode and the higher-order TE_{301} mode. A finite transmission zero close to the resonance of the higher-order TE_{301} mode is generated on the left side of the resonance because the couplings between the input/output and the fundamental TE_{101} mode are larger than that between the input/output and the higher-order TE_{301} mode, and all the couplings have the same sign.

Similarly, a TE_{101}/TE_{201} mode is in operation when the oversized substrate integrated waveguide cavity is asymmetrically excited. The coupling between the input/output and the higher-order TE_{201} mode can reverse when the relative position of the input/output changes from the same half of the cavity to the opposite half of the cavity. This coupling, which reaches a maximum when the input and the output are at an angle of 90°, can be adjusted by changing the relative position of the input/output and the size of the cavity. Therefore, the finite transmission zero can be on the right side or the left side of the resonance of the higher-order TE_{201} mode, and can move slightly closer to the resonance of the fundamental TE_{101} mode to further improve stopband performance.

In the proposed substrate integrated waveguide filter according to FIG. 2, FIG. 3 and FIG. 4, the oversized substrate integrated waveguide cavities which can produce the prescribed finite transmission zeros far away from the passband for the high out-of-band rejection are cascaded to generate the desired passband of the fundamental TE_{101} mode according to the design criterion of the passband. The post-wall iris 7 used for the coupling between the adjacent oversized substrate integrated waveguide cavities is realized by removing some metalized via holes on their common post wall. The first/last substrate integrated waveguide cavity is directly excited by at least one transmission line 1 of either microstrip, stripline or coplanar waveguide, with coupling slots 2 which are used to reduce the size of the input/output coupling post-wall iris for further improvement of the stopband performance without deteriorating the passband performance. The signal whose frequency is in the passband is initially coupled into the first oversized substrate integrated waveguide cavity by the coupling slots 2, and then is coupled into the next cavities by the post-wall iris 7, and at last is fed to the output port 2 with very low loss. On the other hand, an out-of-band signal is attenuated and even blocked at the prescribed finite transmission zeros produced by the corresponding oversized substrate integrated waveguide cavities, which leads to a broad stopband.

FIG. 5, FIG. 6 and FIG. 7 illustrate the typical frequency response curves of three K-band 4^{th}-degree substrate integrated waveguide filters with the same topology as that presented in FIG. 2, FIG.3 and FIG.4, respectively, according to the invention. As can been observed from FIG. 5, FIG. 6 and FIG. 7, the stopband performance is greatly improved, especially over the satellite transmit frequency band of 29.5-30 GHz. The attenuation is better than 50 dB, although only four oversized substrate integrated waveguide cavities are used to maintain low in-band insertion loss.

What is claimed is:

1. A waveguide filter comprising

dielectric substrate

linear arrays of metallic via holes

oversized substrate integrated waveguide cavity

post-wall iris for the coupling between the adjacent oversized substrate integrated waveguide cavities

coupling slots for the signal transmission from the input/output port to the first/last cavity

2. The waveguide filter according to claim 1, wherein said waveguide system is a substrate integrated waveguide system, in which linear arrays of metallic via holes are used to realize side walls on a dielectric substrate by a standard PCB or other planar circuit process for low loss and high performance integration, and the diameter of the via hole and the pitch between adjacent via holes are chosen to suppress the radiation loss.

3. The waveguide filter according to claim 1, wherein an oversized substrate integrated waveguide cavity provides two signal paths for the production of a finite transmission zero through the fundamental mode and higher-order mode.

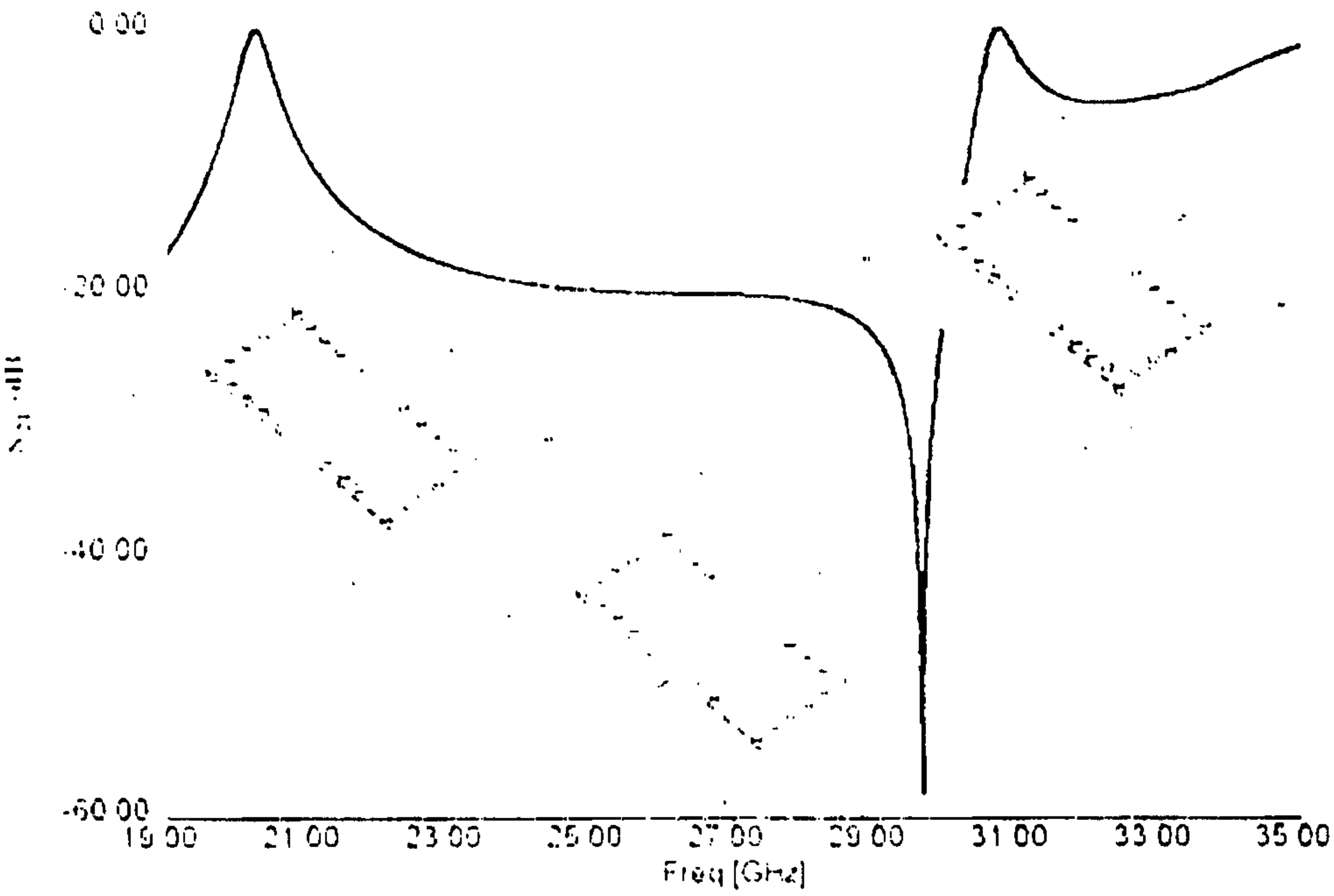
4. The waveguide filter according to claim 1, wherein a post-wall iris is formed by removing some metallic via holes on the common post wall of two adjacent substrate integrated waveguide cavities.

5. The waveguide filter according to claim 1, wherein coupling slots can reduce the size of the input/output post-wall iris and then reduce the dispersion for the further improvement of stopband performance.

6. The waveguide filter according to claim 1, wherein the input/output port comprises at least one transmission line of either microstrip, stripline, or coplanar waveguide.

7. The waveguide filter according to claim 3, wherein the finite transmission zeros produced by the oversized substrate integrated waveguide cavities are located far away from the passband to improve the stopband performance.

8. K-band filters as described with reference to FIG. 1 and as shown in FIG. 2, FIG.3 and FIG. 4 of the accompanying drawings.


0.00
-20.00
-40.00
-60.00
19.00
21.00
23.00
25.00
27.00
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31.00
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35.00
Freq [GHz]

FIG. 1

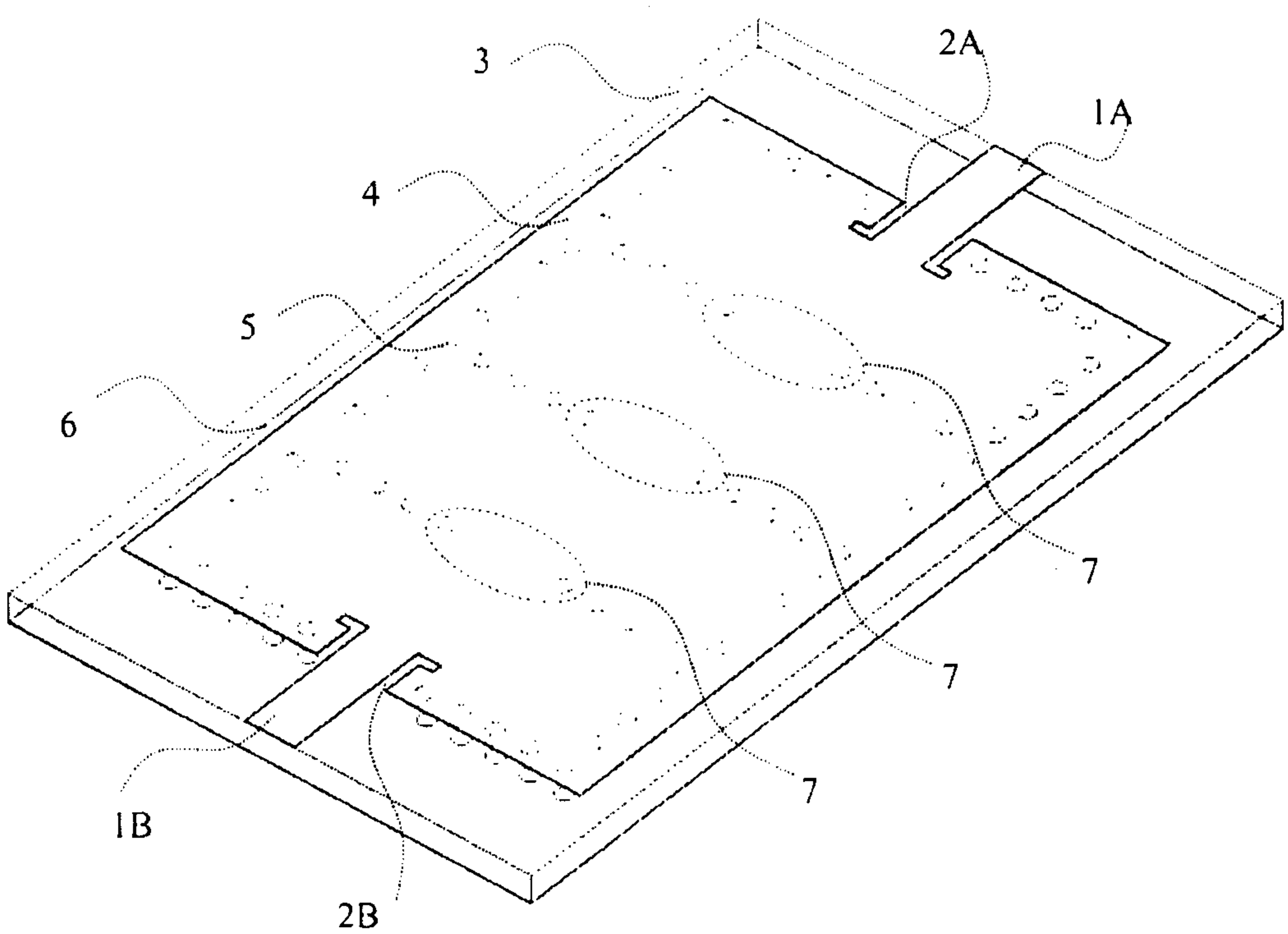


FIG. 2

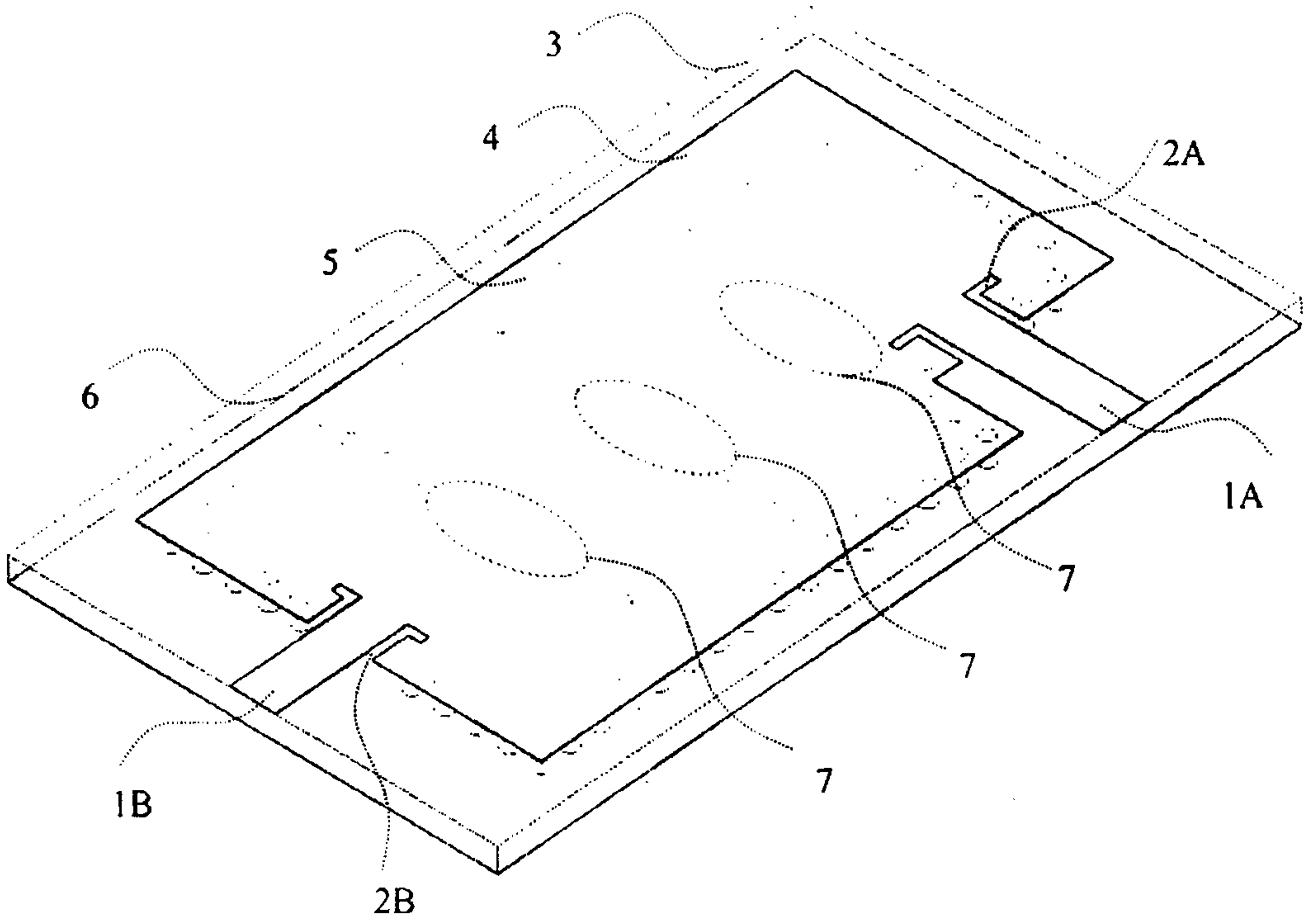


FIG. 3

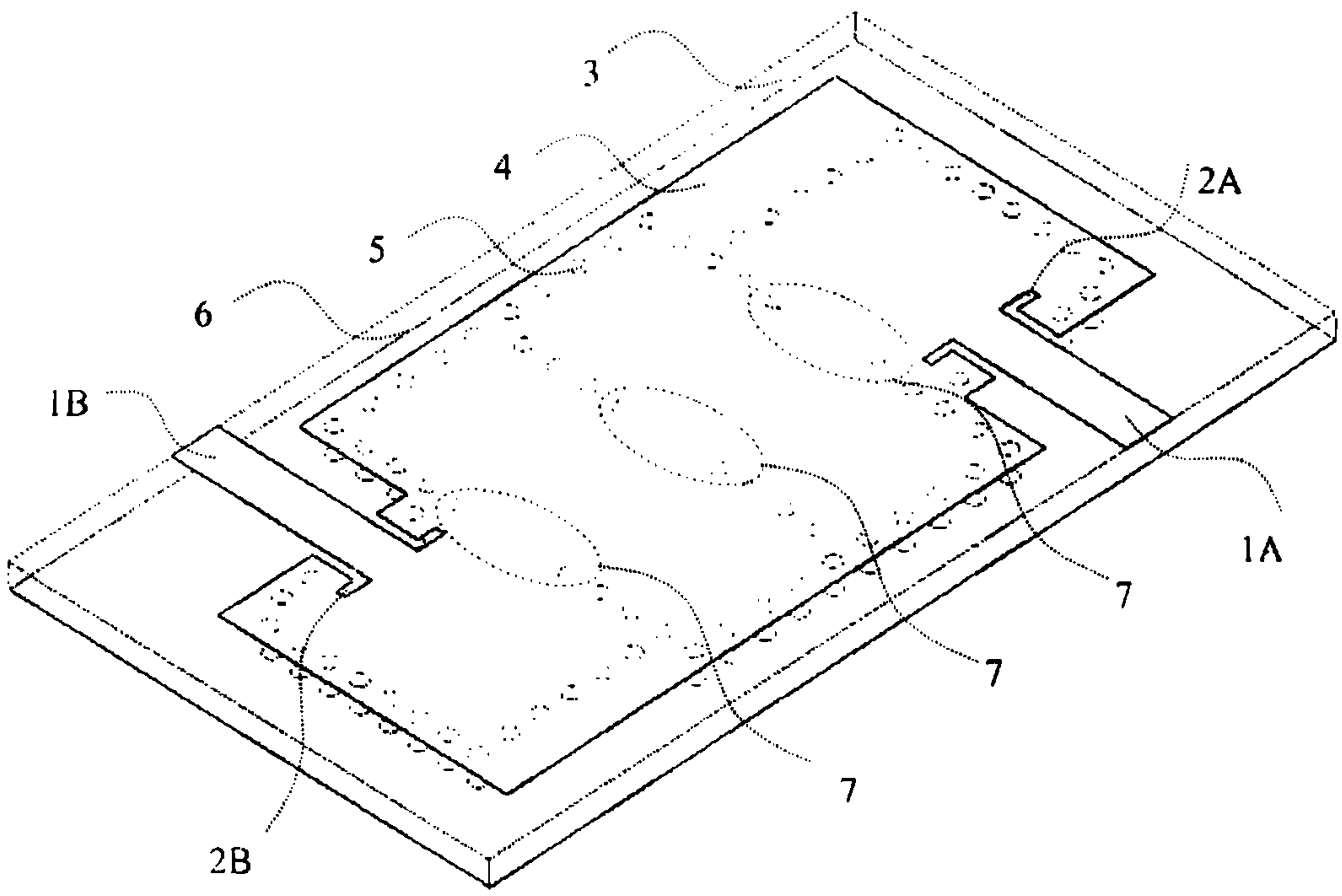


FIG. 4

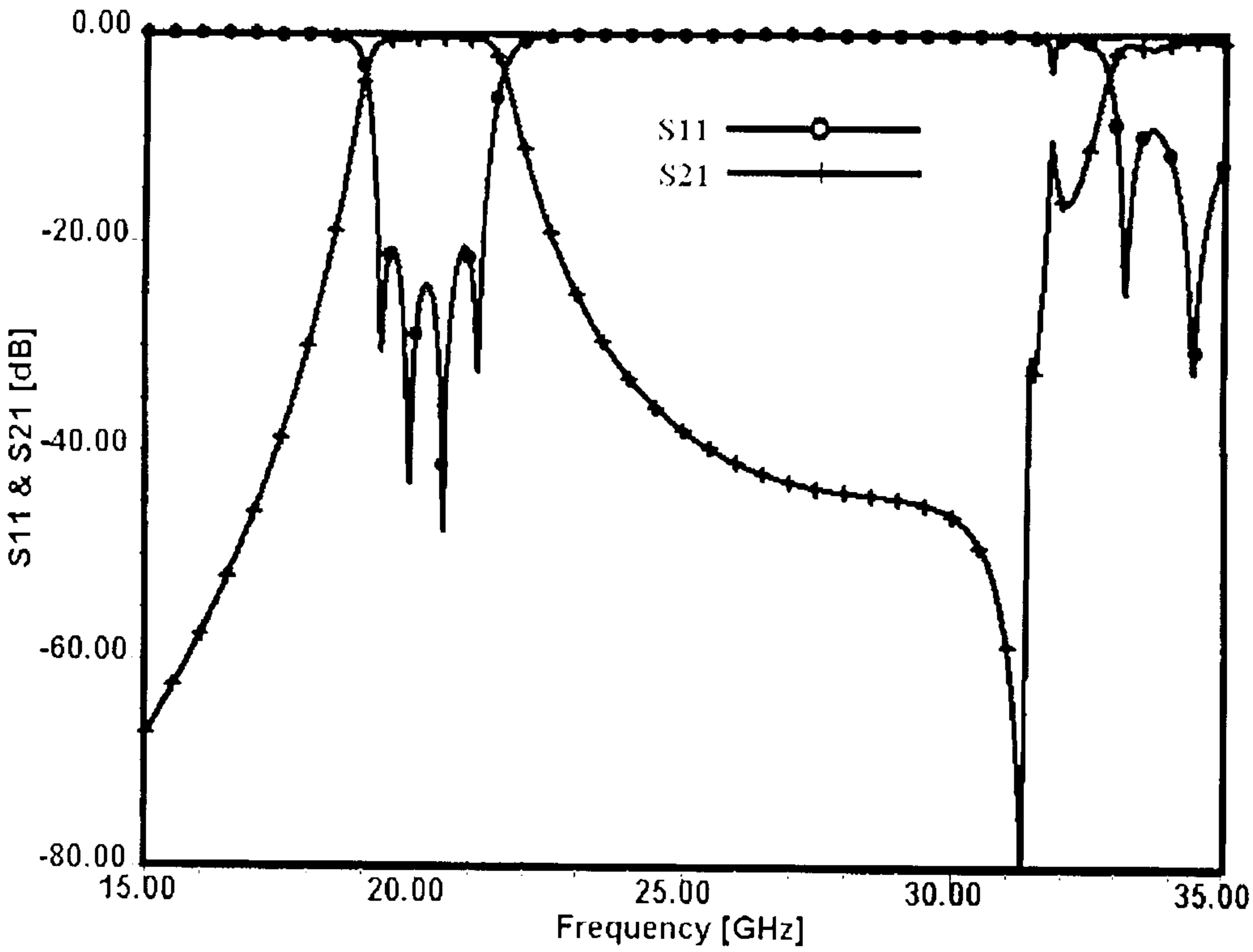
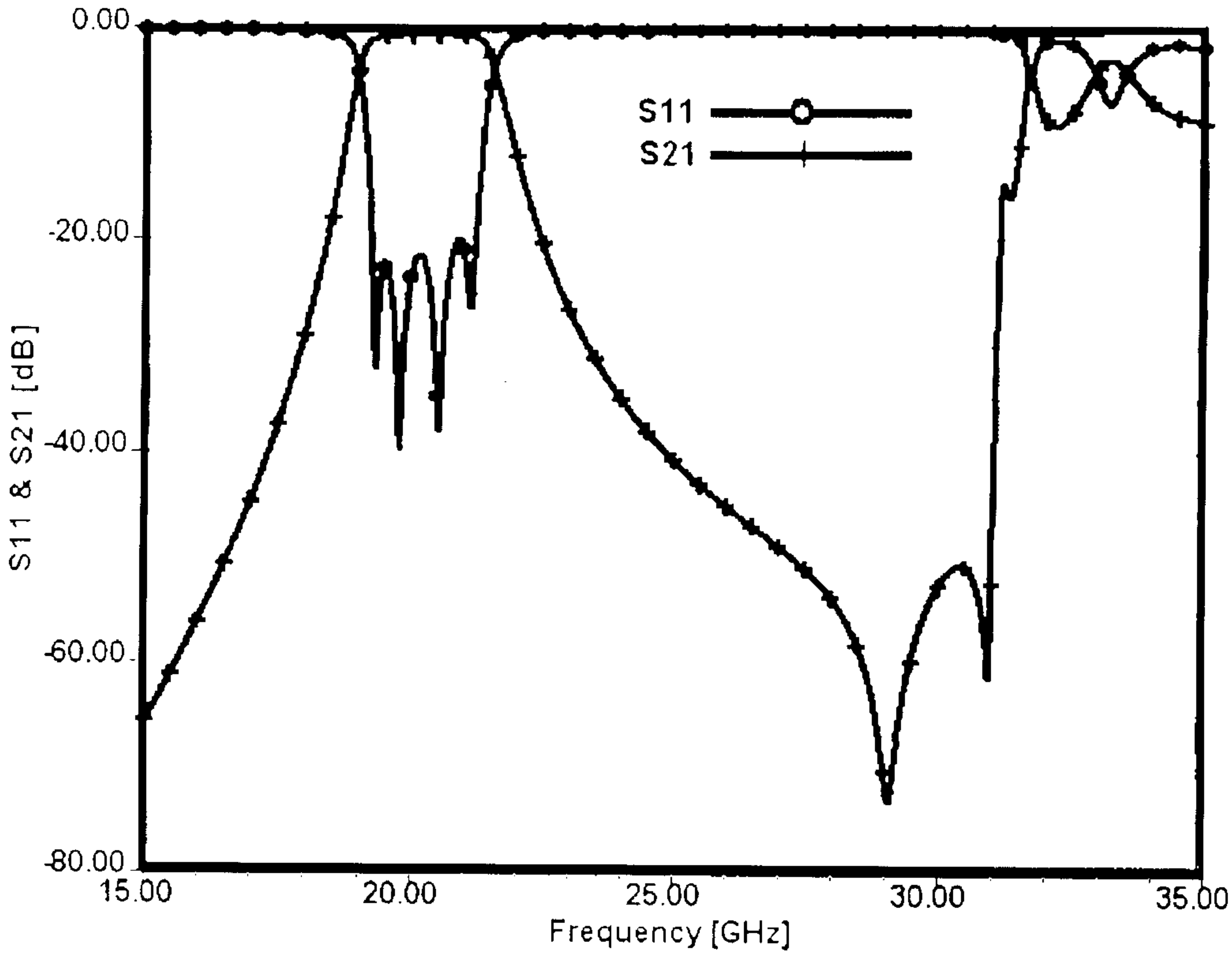

0.00
-20.00
-40.00
-60.00
-80.00
S11 & S21 [dB]
15.00
20.00
25.00
30.00
35.00
Frequency [GHz]
S11
S21

FIG. 5


0.00
-20.00
-40.00
-60.00
-80.00
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35.00
S11 & S21 [dB]
Frequency [GHz]
S11
S21

FIG. 6

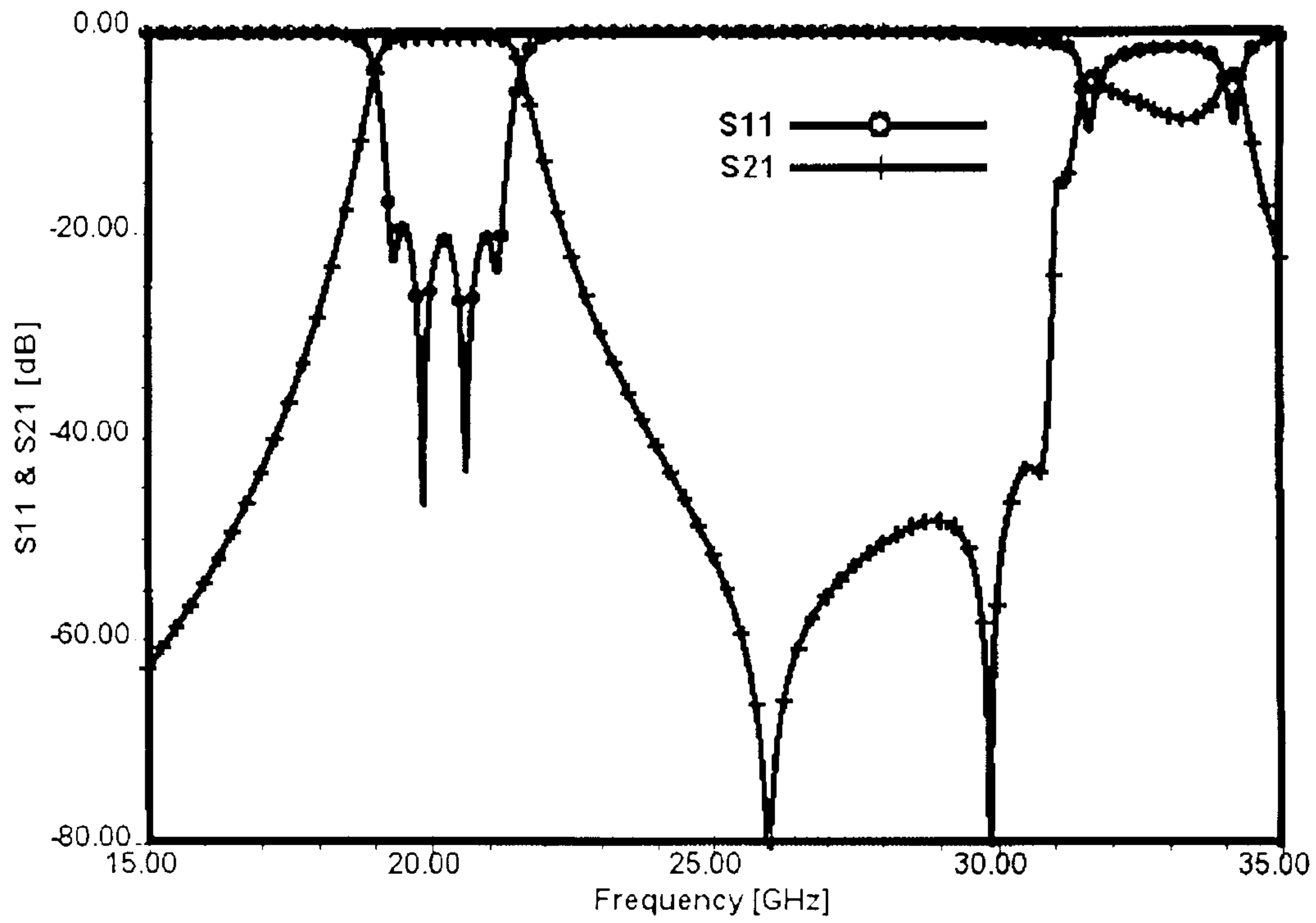
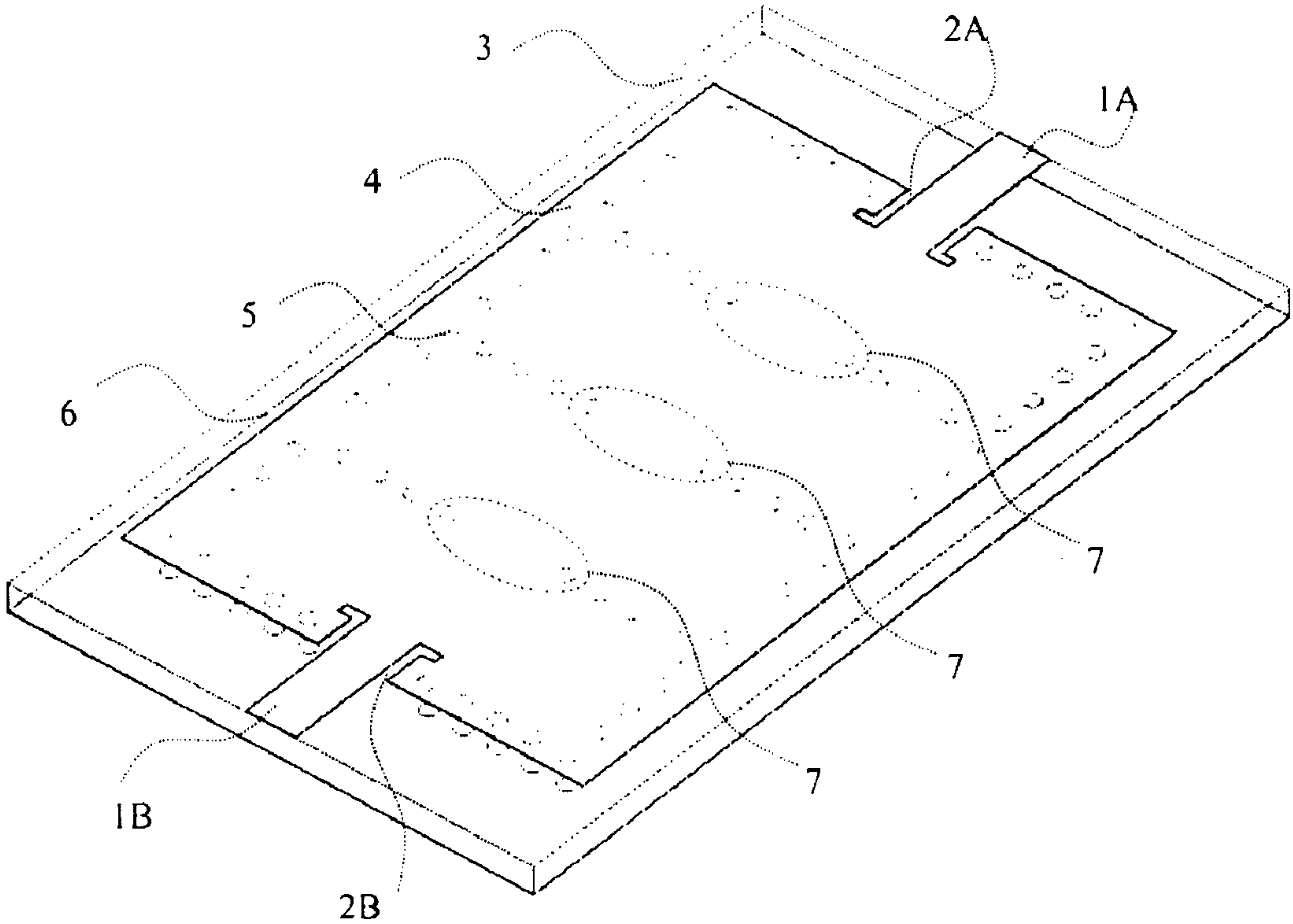

0.00
-20.00
-40.00
-60.00
-80.00
S11 & S21 [dB]
15.00
20.00
25.00
30.00
35.00
Frequency [GHz]
S11
S21

FIG. 7


3
2A
1A
4
5
6
7
7
7
1B
2B