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(54) **Wideband antenna and communications equipment comprising such a wideband antenna**

(57) The application relates to a wideband antenna for use in communications equipment comprising a two-

dimensional wideband antenna element folded back and forth in the third dimension from a first end to a second end, creating meanders.

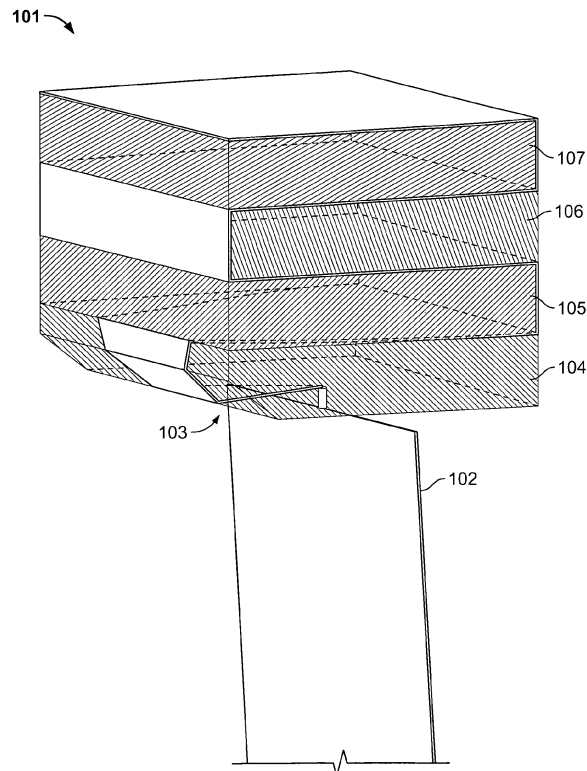


Fig. 1

Description

Background to the Invention

Field of the invention

[0001] The present invention relates to a wideband antenna device of small dimensions and communications equipment using such a wideband antenna

Related art to the invention

[0002] With the success of second generation and third generation wireless communication the fourth generation (4G) or long term evolution (LTE) is now being developed. 4G/LTE mobile communications provide wideband multimedia services at high data rates.

[0003] The LTE specification provides downlink peak rates of at least 100 Mbps and an uplink of at least 50 Mbps and RAN round-trip times of less than 10 ms. LTE supports scalable carrier bandwidths from 1.4 MHz to 20 MHz and supports both frequency division duplexing (FDD) and time division duplexing (TDD). The next step for LTE evolution is LTE advanced and is currently being standardized in 3GPP release 10. The standard includes that five different terminal classes have been defined from a voice centric class up to a high end terminal that supports the peak data rates. All terminals will be able to process 20 MHz bandwidths. There is also increased spectrum flexibility with supported spectrum slices as small as 1.4 MHz and as large as 20 MHz. All frequency plans currently used by IMT systems will be used.

[0004] One of the research challenges in LTE is the broad frequency range i.e. 698 MHz to 2690 MHz, of the interface between the user equipment (UE) and the eN-ODE B. If standard half-dipoles or quarter wavelength monopole antennas were to be used, the size of the antenna would be about 21 cm or 10.5 cm for the low frequency range. This would appear too large for the application in the user equipment, mobile phones for example. Moreover, the bandwidths of standard dipole and monopole antennas are too narrow to cover the operating bands of 4G communications.

[0005] For example, a dipole type wide band antenna comprising a substrate presenting two faces, a first conductive arm, a second conductive arm placed on the substrate and a feeder line supplying the second arm passing under the first arm, is known.

[0006] Further, a class of antenna that comprise an electrically conductive fractal pattern disposed in the dielectric substrate and are capable of construction in a size measured in centimeters as compared to previous antennas of the same class that measure in meters is known. One antenna style has a ground plane that is perpendicular to the substrate and another style has a ground plane that is parallel to the substrate. A bias voltage applied across the substrate can tune the antenna for operation in a particular frequency range. The anten-

na can be made especially wideband by placing an absorbing material behind the substrate.

[0007] None of these antennas however, have the wideband frequency characteristics needed for LTE/4G, nor are they small enough to fit into mobile communications equipment.

[0008] Furthermore, in recent years the usage of antennas in other fields than mobile communications has also increased. For example, there is an increasing need for antennas in the industrial field for, among others, machine to machine communication or in the medical device field for, among others, patient monitoring. Demand has also increased for antennas in the field of home appliances in the pursuit of home automation.

[0009] It follows that an antenna with improved wideband frequency characteristics and compact size is not only desired for mobile communication equipment, but also for non-mobile equipment. Summary of the invention

[0010] It is therefore an object of the present invention to provide small antennas that have wideband properties for wireless communications equipment.

[0011] A further object of the present invention is to provide communications equipment with improved connectivity.

[0012] The above objects are solved by a wideband antenna as defined in claim 1 and communications equipment as defined in claim 12, respectively. Preferred embodiments of the invention are defined by the dependent claims. Communications equipment in the sense of the present invention refers to either mobile equipment, such as user equipment (UE), mobile phone, mobile hand-held device, wireless modem for a laptop computer, laptop computer, vacuum cleaner, etc, or non-mobile equipment, such as industrial machines, home appliances, medical devices, etc. Hence, non-mobile equipment in the sense of the present invention refers to a device which is normally not intended to be carried and/or moved around by the user, i.e. it is usually a stationary device. In the field of home appliances, a coffee machine or a refrigerator are examples of non-mobile equipment in the sense of the present invention.

[0013] In an advantageous embodiment a wideband antenna for use in communications equipment comprises a two-dimensional wideband antenna element folded back and forth in the third dimension from a first end to a second end creating meanders. This has the advantage of a reduced size of the antenna compared to the conventional or quarter wave dipoles.

[0014] In a further advantageous embodiment the two-dimensional wideband antenna element increases in width from the first end to the second end, therefore making the antenna wideband.

[0015] In a further advantageous embodiment dielectric elements are located in the meanders of the two-dimensional wideband antenna element changing the frequency characteristics of the wideband antenna, and therefore making it possible to make the antenna even smaller.

[0016] In a further embodiment the two-dimensional wideband antenna element is folded to create two meanders, each comprising one dielectric element, and in a further embodiment the two-dimensional wideband antenna element is folded to create four meanders, each comprising one dielectric element, the number of meanders making the prediction of the antenna characteristics easier.

[0017] In another embodiment the two-dimensional wideband antenna element is of triangular shape or of a combination of triangular, rectangular or polygonal shapes, which increases the wideband properties of the antenna.

[0018] In a further advantageous embodiment the two-dimensional wideband antenna element is a Vivaldi antenna, thus improving the wideband properties of the antenna.

[0019] In a further advantageous embodiment the two-dimensional antenna element is tuned to a frequency band within 698HMz to 2690HMz, thereby covering the LTE/4G operating frequencies.

[0020] In a further advantageous embodiment the two-dimensional antenna element is made of a conductive metal, preferably copper or silver, which means that the radiation properties are improved.

[0021] In another embodiment the two-dimensional antenna element is connected to a printed circuit board or to a chassis of the mobile communications equipment to provide grounding. The antenna can either be directly in contact with the PCB as such, for example, via an RF input/output of the PCB, or indirectly via, for example, an RF input/output mounted on the chassis (grounding) of the communications equipment.

[0022] In a further advantageous embodiments dielectric elements can have a dielectric constant of more than 10, thus making it possible to make the antenna smaller than a conventional antenna.

Brief description of the drawings

[0023] In the accompanying drawings:

Figure 1 shows a quad-folded antenna with 4 layers of dielectrics;

Figure 2 shows the antenna of Figure 1 without dielectrics;

Figure 3 shows a double-folded antenna with two layers of dielectrics;

Figure 4 represents the S11 coefficients with various dielectric constants EPSR2 in graphical format; and

Figure 5 shows the Voltage Standing Wave Ratio of the double-folded antenna of Fig. 3 when in a device.

Detailed description of the invention

[0024] Herein a more detailed description based on preferred embodiments of the present invention with reference to the accompanying drawings is provided.

[0025] First, a preferred embodiment will be described. However, the present invention shall not be construed as limited to the embodiments set forth herein. Rather these embodiments are provided so that this disclosure will be thorough and complete and more fully convey the scope of the invention to those skilled in the art. In the drawings, like numbers refer to like elements throughout.

[0026] In particular, the antenna of the invention is described in the context of being used in mobile communications equipment in an LTE or 4G network. It is, however, conceivable that small wideband antennas like those of the invention could be used in many different circumstances, including fixed wireless access, WLAN, WiFi, etc.

[0027] Throughout the following description, the wideband antenna is described as being used in mobile communications equipment which could be a user equipment (UE), mobile phone, mobile hand-held device, wireless modem for a laptop computer etc. The antenna could, however, also be used in non-mobile devices, such as home appliances, industrial machines, medical devices, etc.

[0028] Figure 1 shows a quad-folded antenna 101 that is connected to ground, preferably a PCB board 102, via the feeding point 103. The quad-folded antenna is a Vivaldi or triangular antenna increasing in width from a first end at feeding point 103 to a second end at open space. The quad-folded antenna 101 is preferably made of conducting metal and joined to an RF input/output, i.e. on the PCB board, by a metal strip. The quad-folded antenna 101 is at right angles to ground 102 at the feeding point 103. Then it is folded at least back on itself twice and creates a meander for the first layer of dielectric 104. With another two folds at 90° each, the quad-folded antenna 101 is folded back on itself again to create another meander or loop or space for the second layer of dielectric 105. Again, the antenna is folded back on itself by two folds of 90° to create a space or meander or loop for the third layer of dielectric 106. The fourth layer of dielectric 107 is inserted in the last meander or loop or space that is created by another two folds at 90° so that the quad-folded antenna is folded back on itself.

[0029] In the embodiment of Fig. 1 the quad-folded antenna starts off narrow at the feeding point 103 and gains in width up to the second set of folds leading from the first to the second meander. From thereon, the quad-folded antenna 101 is of rectangular shape. The quad-folded antenna can be of any WB (wideband) shape that is two-dimensional and can therefore be folded.

[0030] The two-dimensional shape of the quad-folded antenna before folding is triangular or a combination of triangular, rectangular and polygonal or the antenna is of a Vivaldi shape. The two-dimensional antenna is fold-

ed into the third dimension making this a three-dimensional quad-folded antenna 101.

[0031] It is found that additional resonant frequencies can be gained by this quad-folded antenna 101. The additional frequencies depend on the electric properties of the dielectrical elements 104..107 in the first, second, third and fourth layers. If high dielectric constants for these dielectric elements are chosen, the lowest additional frequency of the antenna can be located at the low frequency range of the LTE frequency spectrum, i.e. 698 MHz to 2690 MHz.

[0032] Figure 2 shows the quad-folded antenna 101 of Figure 1 without the dielectric elements inserted in the first, second, third and fourth layer, in order to show the shape of the quad-folded antenna 101 more clearly. Also, an exemplary feeding point 103 is shown.

[0033] Figure 3 shows a double-folded Vivaldi/triangular antenna 201 with two layers of dielectric. The double-folded antenna 201 is connected to ground 202, which is preferably a PCB board, via a feeding point (not shown). The antenna of Figure 3 has two meanders or loops or spaces for a first layer of dielectric element 204 and a second layer of dielectric element 205.

[0034] This is the kind of antenna that can be employed in mobile equipment like user equipment (UE) or mobile phone as the size of the antenna in this example would be 50 mm x 15 mm x 14 mm, the thickness of the dielectrics would be 7 mm and the size of the ground plate would be 50 mm x 100 mm.

[0035] Figure 4 shows the reflection coefficient S11 in dB with three different dielectric constants in dB over a frequency range of 0-5 GHz. The solid line that shows the results for a dielectric constant of 1 is fairly smooth and it can be clearly seen that when the dielectric constant is higher, say 11 or 21, additional resonant frequencies are introduced. It is found that an additional resonant frequency can be obtained in the low frequency range. The property can be used effectively to lower the operating frequency or to reduce the volume of the antenna.

[0036] The curves in Fig. 4 show that the resonant frequencies of antenna 201 change with the material used as the dielectric element or dielectric slab 204, 205. The return loss characteristic is a measure of the energy reflected back to the feed at the antenna input terminals and, hence, shows the impedance match of the antenna with standard feeding configurations. When connected to a port of a properly calibrated network analyzer, the return loss is measured as S11. Direct results confirm that the antenna configuration remains multiband, and is not greatly perturbed by the substrate properties. The higher the dielectric constant the lower the minimum operational frequency of the antenna is. Antenna 201 improves the multiband frequency/return loss characteristic. When the dielectric elements 204, 205 have a high dielectric constant above 10, the multiband performance is moved in the frequency range making the antenna relatively smaller for the desired frequency range in the LTE spectrum.

[0037] Figure 5 shows the voltage standing wave ratio (VSWR) of the double-folded antenna of Figure 3 when in a device, over a frequency range of 0-3 GHz. It is shown that the antenna can operate in the frequency range of 690 MHz to 2865 MHz, as its VSWR is smaller than or equal to 3 in this frequency range. Therefore, the double-folded Vivaldi/triangular antenna is suitable for the application of 3G and 4G/LTE mobile communications.

Claims

1. A wideband antenna (101, 201) for use in communications equipment, comprising:
 - a two-dimensional wideband antenna element folded back and forth in the third dimension from a first end to a second end, creating meanders.
2. The wideband antenna (101) according to claim 1, wherein the two-dimensional wideband antenna element increases in width from the first end to the second end.
3. The wideband antenna (101, 201) according to claim 1 or 2, further comprising:
 - dielectric elements (104..107, 204, 205) located in the meanders of the said wideband antenna.
4. The wideband antenna (201) according to any of claims 1 to 3, wherein the two-dimensional wideband antenna element is folded to create two meanders, which each comprise one dielectric element (204, 205).
5. The wideband antenna (101) according to any of claims 1 to 3, wherein the two-dimensional wideband antenna element is folded to create four meanders which each comprise one dielectric element (104..107).
6. The wideband antenna according to any of claims 1 to 5, wherein the two-dimensional wideband antenna element is of triangular shape, or of a combination of triangular, rectangular or polygonal shape.
7. The wideband antenna according to any of claims 1 to 5, wherein the two-dimensional wideband antenna element is a Vivaldi antenna.
8. The wideband antenna according to any of claims 1 to 7, wherein the two-dimensional antenna element is tuned to a frequency band within 698MHz to 2690MHz.
9. The wideband antenna according to any of claims 1 to 8, wherein the two-dimensional antenna element

is made of a conductive metal, preferably copper or silver.

10. The wideband antenna according to any of claims 1 to 9, wherein the first end of the two-dimensional antenna element is connected to printed circuit board or to a chassis of the communications equipment. 5
11. The wideband antenna according to any of claims 1 to 10, wherein the dielectric elements have a high dielectric constant of more than 10. 10
12. Communications equipment comprising a wideband antenna according to any of the preceding claims. 15

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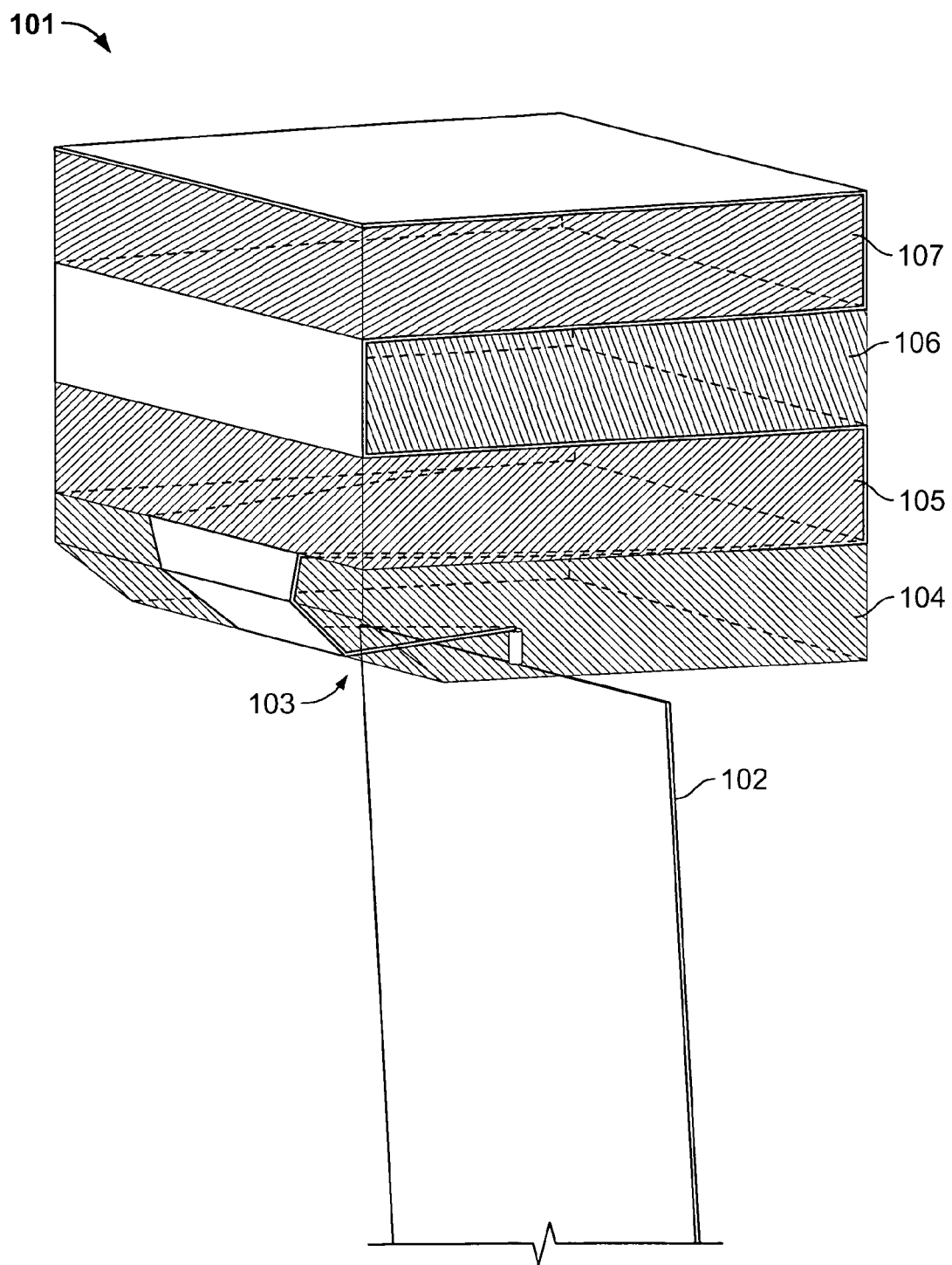


Fig. 1

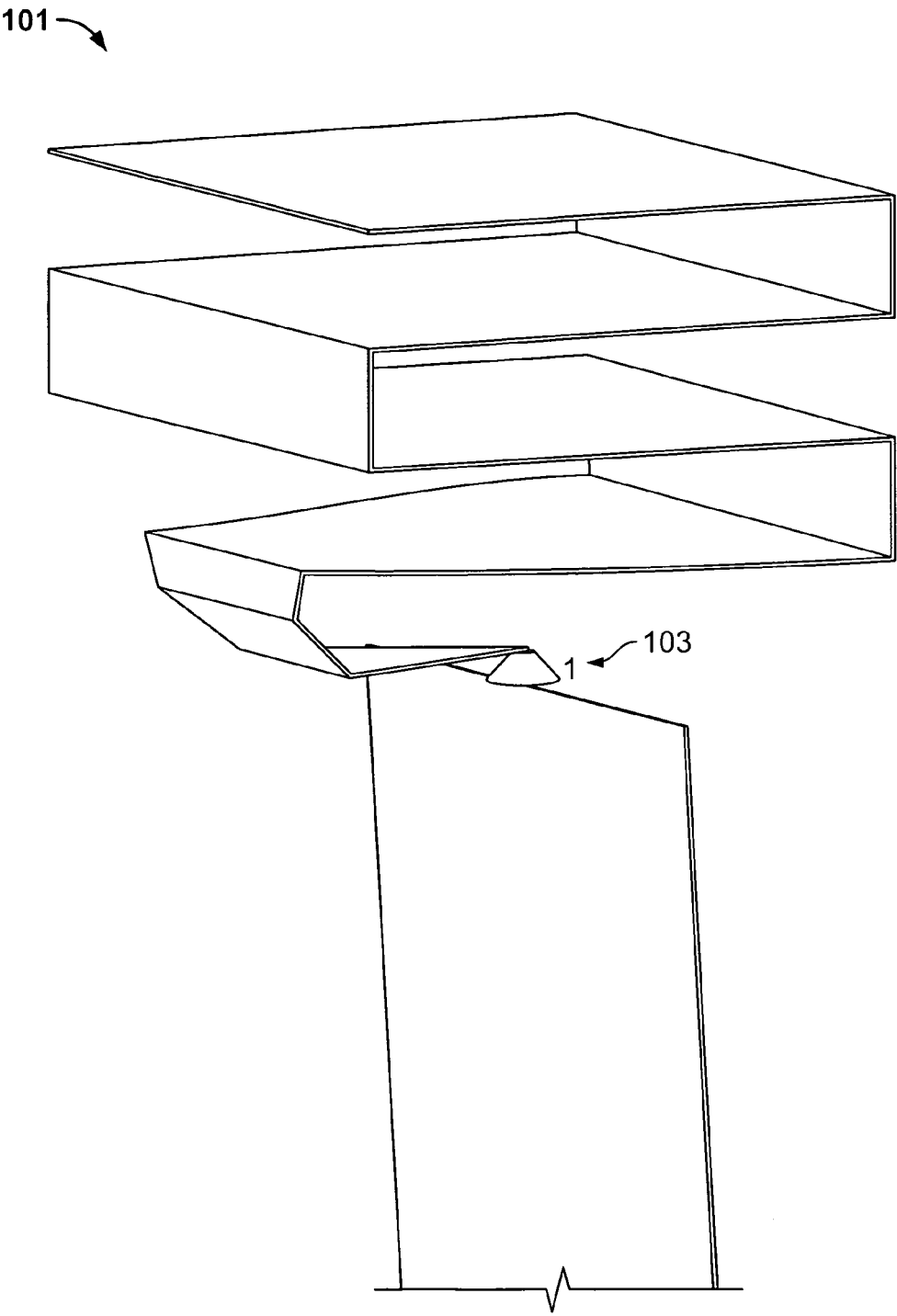


Fig. 2

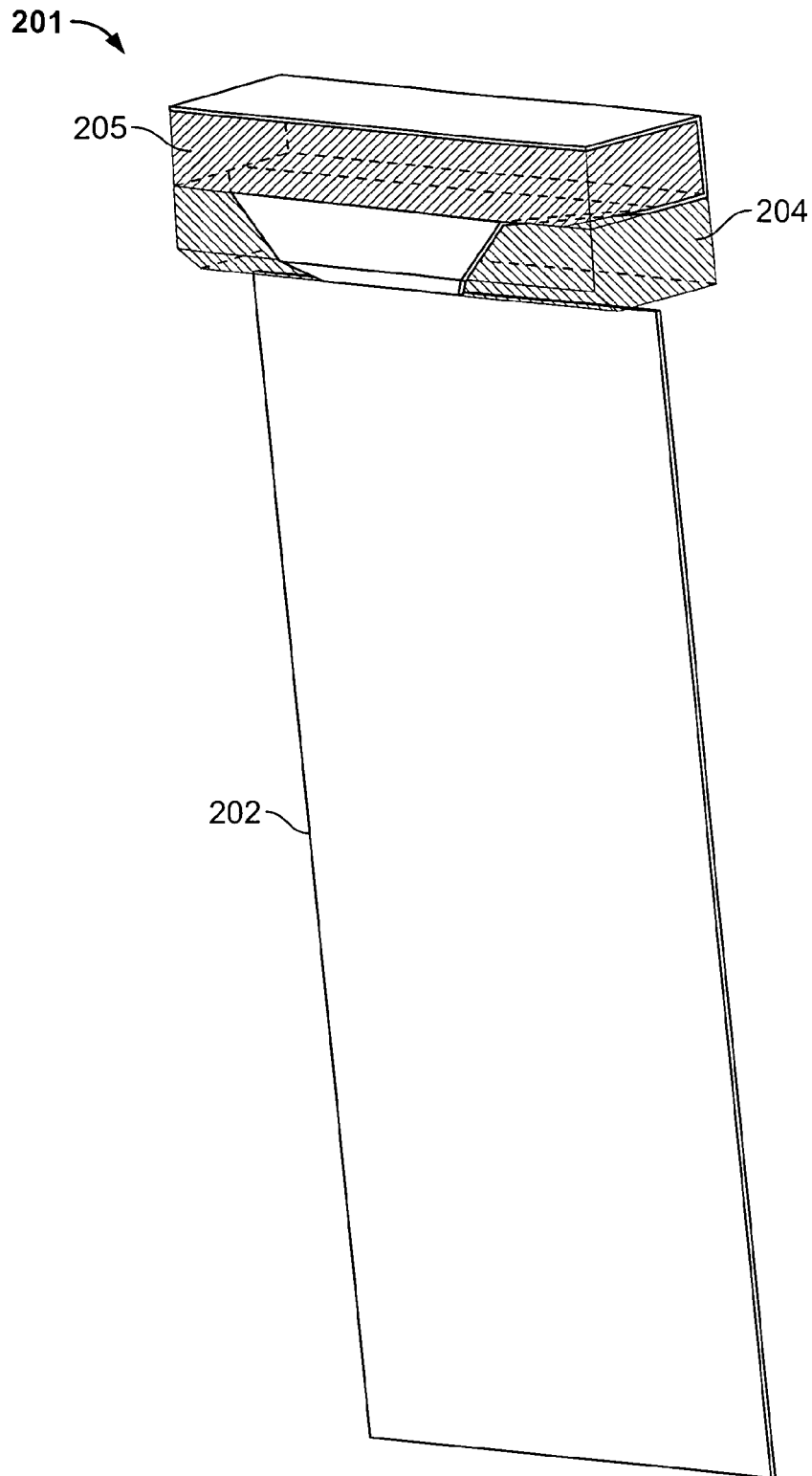


Fig. 3

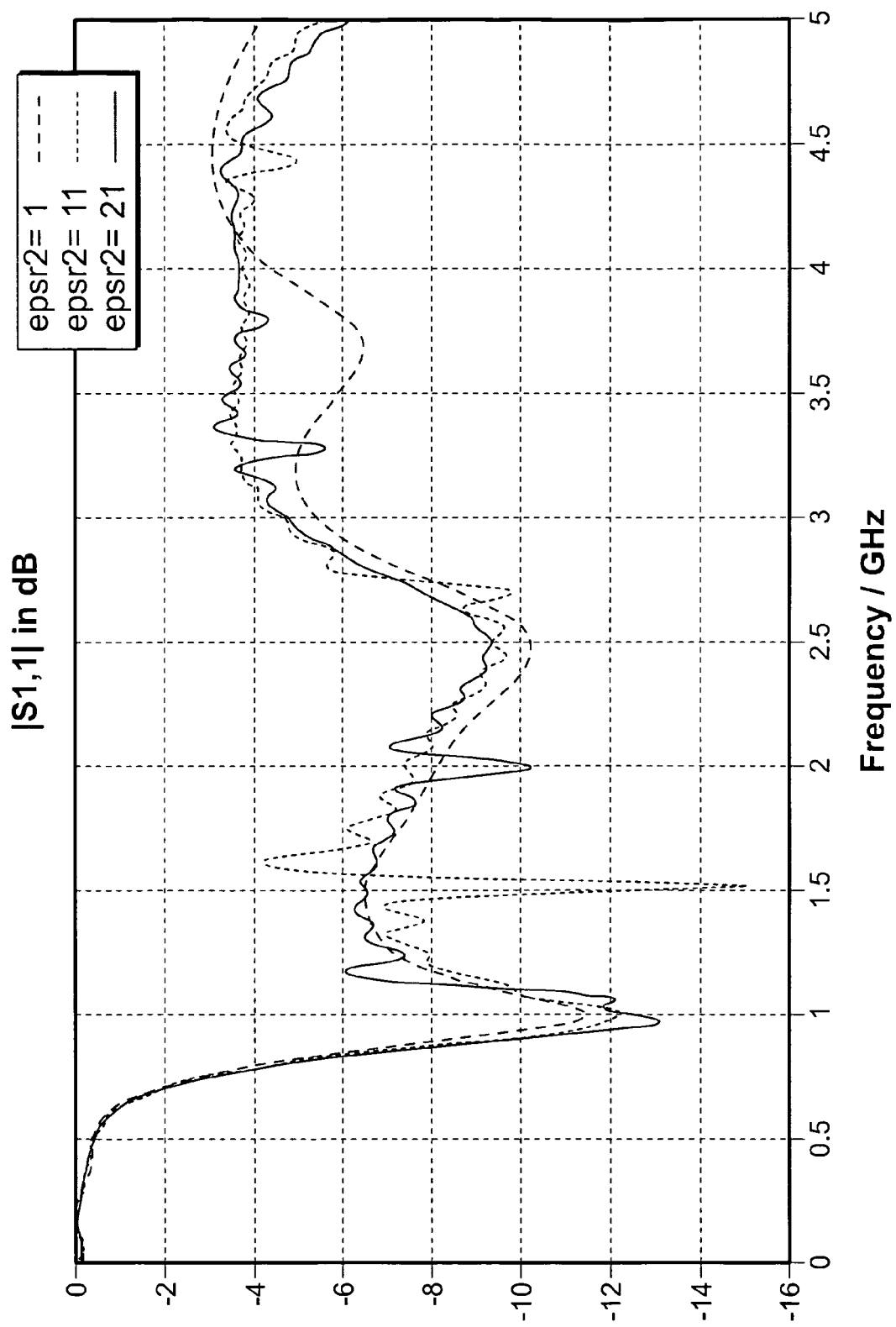


Fig. 4

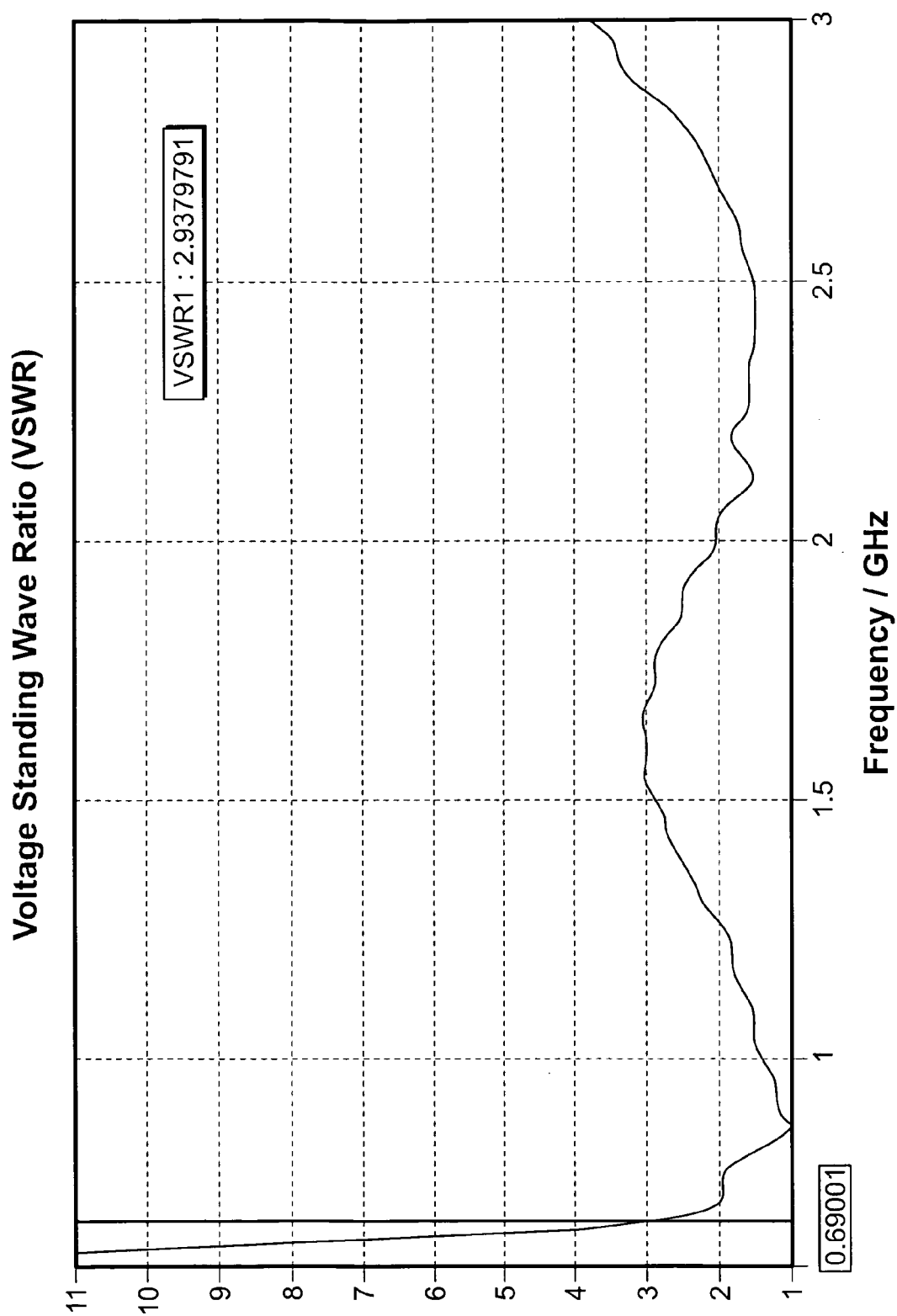


Fig. 5



EUROPEAN SEARCH REPORT

Application Number
EP 10 01 3276

DOCUMENTS CONSIDERED TO BE RELEVANT			
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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
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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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