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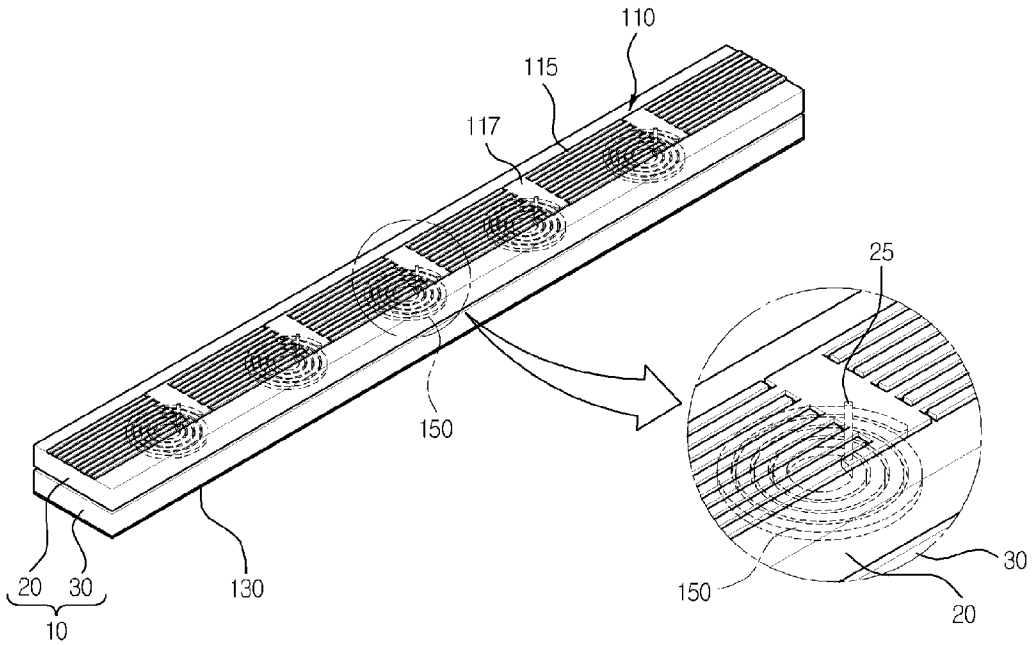
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(54) **Title:** TRANSMISSION LINE



(57) **Abstract:** The present invention relates to a transmission line in which a physical value of an inductive element can be changed in various ways while minimizing a size. The transmission line of the present invention includes a transmission unit, a ground unit and inductive elements. The inductive element connects the transmission unit and the ground unit, and has a predetermined pattern. The inductive element is provided between two surfaces of a substrate. According to the present invention, a physical value of the inductive element, in particular, an inductance value can be changed in various ways while not increasing an overall size. Accordingly, a transmission line can be designed freely according to its application.

WO 2008/023931 A1

Description

TRANSMISSION LINE

Technical Field

[1] The present invention relates to a transmission line, and more particularly, to a transmission line which enables various modifications of physical values of inductive elements and miniaturization of a device through the improvement of a structure.

Background Art

[2] In general, a transmission line refers to a conductor system consisting of several conductors, and employing a propagation operation of a wave by electrical parameters, which are distributed between conductors, for example, such as resistance, inductance, conductance, and capacitance per unit length.

[3] Recently, active researches have been conducted on methods of implementing a Left-Handed (LH) characteristic by employing this transmission line. The LH characteristic refers to a characteristic in which the propagation directions of an electric field, a magnetic field, and electromagnetic waves comply with Fleming's left hand rule contrary to Fleming's right hand rule, and is related with a theory of artificial "metamaterial." The term "metamaterial" generally refers to a material, which is synthesized by an artificial method so as to exhibit special electromagnetic properties that can be seen rarely in the natural world.

[4] A construction of the transmission line having the LH characteristic will be described below with reference to FIGS. 1 and 2.

[5] while a typical transmission line equivalent model is represented by an equivalent circuit of a serial inductor and a parallel capacitor, in a transmission line structure comprising a serial capacitor and a parallel inductor in which the positions of the serial inductor and the parallel capacitor are exchanged, there occurs a phenomenon in which the phase velocity of electromagnetic waves transmitted through the transmission line structure is reversed.

[6] FIG. 1 shows an equivalent circuit of the transmission line having the serial capacitor and the parallel inductor. In this transmission line, when a phase velocity and a group velocity are calculated, a LH propagation characteristic is obtained in which the phase and group velocities are oriented in opposite directions.

[7] Meanwhile, a more general structure in which a transmission line (hereinafter, referred to as a 'RH transmission line') representing a Right-Handed (RH) characteristic and a transmission line (hereinafter, referred to as a 'LH transmission line') representing a LH characteristic are integrated has been known as a transmission line (hereinafter, referred to as a 'CRLH transmission line') representing a Composite

Right/Left Handed (CRLH) characteristic. An equivalent circuit of a CRLH transmission line is shown in FIG. 2.

[8] The structure arranged as shown in FIG. 2 has the characteristic of the LH or RH transmission line depending on whether the influence of any one of the inductor and the capacitor of a serial connection unit and a parallel connection unit is significant in a specific frequency band.

[9] The structure has a stopband characteristic at a resonant frequency of the serial unit and the parallel unit. This fact can be easily confirmed in the transmission characteristic of the general CRLH transmission line shown in FIG. 2. In more detail, at a low frequency band, the LH transmission characteristic mainly appears due to the action of a serial capacitor C_L and a parallel inductor L_L, whereas at a high frequency band, the RH transmission characteristic mainly appears due to the action of a serial inductor L_R and a parallel capacitor C_R. A stopband of electromagnetic waves exists between the two regions.

[10] A construction of a transmission line in which the CRLH transmission line model is implemented actually will be described below with reference to FIG. 3.

[11] In an actual implementation, each inductor and each capacitor can be implemented as a concentrated constant circuit by mounting a capacitive element and an inductive element of a Surface Mount Device (SMD) chip type or as distributed constant circuit by forming an IDT (interdigital) capacitive element and an inductive element on a circuit pattern.

[12] FIG. 3 shows an example of a conventional CRLH transmission line constructed by forming an IDT capacitive element and an IDT inductive element on a circuit pattern.

[13] The conventional transmission line largely includes capacitive elements 10, inductive elements 50 and a ground unit 30.

[14] The capacitive elements 10 have an IDT pattern and are arranged at predetermined intervals in the length direction. The inductive elements 50 are formed on the same plane as that of the capacitive element 10, and have a stub shape projecting between the capacitive elements 10 in a lateral direction.

[15] The ground unit 30 has a ground surface form provided on the other side of a substrate 1, and is electrically connected to one ends of the inductive elements by conductive connection elements 15. The connection elements 15 can be formed through via holes penetrating both surfaces of the substrate 1.

[16] The serial capacitor C_L is formed by the capacitive element 10 having the IDT pattern, and the parallel inductor L_L is formed by the inductive element 50 whose ends are shorted.

[17] A parasitic capacitive component between an IDT structure and a ground surface forms the parallel capacitor C_R. The serial inductor L_R is formed by current existing on

the IDT pattern and entire structure operates as the CRLH transmission line.

[18] However, the above conventional transmission line has the following problems.

[19] The serial capacitor can have a flexible capacitance value by controlling an detailed shape of IDT, a distance between the elements and so on, but has many limitations in changing an inductance value in the inductor. In other words, in order to increase the inductance, the length of the inductive element projecting in a lateral direction on the same plane as that of the capacitive element must be increased. Accordingly, there was a problem in that the width of the substrate increases, resulting in an increase of the overall size of a device.

[20] Meanwhile, unlike the above method, the inductive element can be formed from a conductive material formed in the via hole between the substrates. In this case, however, there was a problem in that the inductance value could not be changed according to a design condition since the width, material, etc. of the substrate are defined.

Disclosure of Invention

Technical Problem

[21] Accordingly, the present invention has been made in view of the above problems occurring in the prior art, and an object of the present invention is to provide a transmission line which can miniaturize a device and can increase an inductance value through improvement of a structure.

[22] Another object of the present invention is to provide a transmission line whose shape can be designed freely in order to actively cope with required conditions.

Technical Solution

[23] To achieve the above objects, the present invention provides a transmission line, including a conductive transmission unit formed on one surface of a substrate and adapted to transmit an electrical signal, a ground unit formed on the other surface of the substrate, and inductive element formed to have a predetermined pattern between two surfaces of the substrate and adapted to interconnect the transmission unit and the ground unit so as to ground the transmission unit.

[24] The transmission unit includes one or more capacitive elements disposed at pre-determined intervals in the length direction. The capacitive element has an IDT-shaped pattern.

[25] Meanwhile, the inductive element includes a helical element extending upwardly and downwardly between the surfaces of the substrate. And the substrate is formed in plural, and the inductive element is formed on a junction surface between the plurality of substrates.

[26] Furthermore, the inductive element includes a spiral-shaped element. The inductive

element is connected to the transmission unit or the ground unit by means of conductive connection element, and the connection element has a helical shape.

Advantageous Effects

[27] The transmission line according to the present invention as constructed above has the following advantages.

[28] First, the inductive elements are provided between both surfaces of the substrate. Accordingly, there is a benefit in that an inductance value can be changed in various ways. That is, a device can be miniaturized since a space utilization degree of the transmission line is increased. Further, an inductance value can be increased while minimizing the size of the transmission line.

[29] Second, there is a benefit in that a transmission line can be designed actively in line with a desired frequency band according to a desired condition. In more detail, an inductance value to meet a desired design condition can be implemented by modifying the shape of the inductive elements provided between both surfaces of the substrate in various ways.

Brief Description of the Drawings

[30] Further objects and advantages of the invention can be more fully understood from the following detailed description taken in conjunction with the accompanying drawings in which:

[31] FIG. 1 is a circuit diagram showing an equivalent circuit of a general LH transmission line;

[32] FIG. 2 is a circuit diagram showing an equivalent circuit of a general CRLH transmission line;

[33] FIG. 3 is a perspective view showing a construction of a conventional CRLH transmission line;

[34] FIG. 4 is a perspective view schematically illustrating a transmission line according to a first embodiment of the present invention;

[35] FIG. 5 is a lateral view of FIG. 4;

[36] FIG. 6 is a perspective view illustrating an inductive element and a connection element of FIG. 4;

[37] FIG. 7 is a perspective view schematically illustrating a transmission line according to a second embodiment of the present invention; and

[38] FIG. 8 is a lateral view of FIG. 7.

Best Mode for Carrying Out the Invention

[39] The present invention will now be described in detail in connection with specific embodiments with reference to the accompanying drawings.

[40] A construction of a transmission line according to a first embodiment of the present

invention will be described below with reference to FIGS. 4 to 6.

[41] FIG. 4 is a perspective view schematically illustrating a transmission line according to a first embodiment of the present invention. FIG. 5 is a lateral view of FIG. 4. FIG. 6 is a perspective view illustrating an inductive element and a connection element of FIG. 4.

[42] The transmission line in accordance with the present embodiment largely includes a transmission unit 110, a ground unit 130 and inductive elements 150.

[43] The transmission unit 110 is provided on one surface of the substrate 10, and transmits an electrical signal. The substrate 10 can be preferably formed from a dielectric material having an insulating property. The transmission unit 110 can be formed from a thin metal element on the substrate 10 or can be formed by coating a conductive material on the substrate 10 by a method such as etching.

[44] Meanwhile, the transmission unit 110 includes capacitive elements 115 and stubs 117 that are repetitively arranged in the length direction.

[45] In the present embodiment, the capacitive elements 115 have elements of an IDT pattern in such a manner that the elements are geared with each other at predetermined intervals as shown FIG. 4. The stub 117 is provided between the capacitive elements 115, and is electrically connected to the inductive element 150 by a first connection element 25 to be described later on.

[46] The ground unit 130 is provided on the other surface of the substrate 10, and is connected to the transmission unit 110 via the inductive element 150. The ground unit 130 functions to ground the transmission unit 110. In the present embodiment, the ground unit 130 has a ground surface form formed on the bottom of the substrate 10.

[47] The inductive element 150 is provided between both surfaces of the substrate 10, and has a predetermined pattern and a constant inductance value.

[48] Meanwhile, in the present embodiment, the substrate 10 includes a first substrate 20, and a second substrate 30 adhered under the first substrate 20. The transmission unit 110 is provided on the top surface of the first substrate 20 and the ground unit 130 is provided on the bottom surface of the second substrate 30, as shown in FIG. 5.

[49] The inductive element 150 has a thin film shape of a thin thickness in the longitudinal direction, and is provided on the junction surface of the first substrate 20 and the second substrate 30.

[50] The inductive element 150 is not limited to the above shape, but may be changed according to various design conditions. The present embodiment illustrates a shape having a spiral-shaped element as shown in FIG. 6. In this case, an inductance value can be changed by controlling the size, distance, etc. of the spiral-shaped element.

[51] The inductive element 150 is electrically connected to the transmission unit 110 and the ground unit 130 by conductive connection elements 25 and 35. The substrate 10

has both surface penetrated through via holes. The conductive connection elements 25 and 35 are provided on the via holes, enabling electrical connection between the elements.

[52] In more detail, the inductive element 150 and the transmission unit 110 are electrically connected to each other by the first connection element 25 provided in the first substrate 20, and the inductive element 150 and the ground unit 130 are electrically connected to each other by the second connection element 35 provided in the second substrate 30.

[53] The first and second connection elements 25 and 35 are not limited to the above shapes. In the present embodiment, it has been illustrated that the connection elements 25 and 35 have a cylindrical shape formed from a conductive material as shown in FIG. 6. Further, the inductive element 150 and the connection elements 25 and 35 can be formed integrally, or can be formed separately and then combined together.

[54] In the transmission line constructed above, a serial capacitor C_L is formed by the capacitive element 115 having the IDT pattern, and the parallel inductor L_L is formed by the inductive element 150 provided between both surfaces of the substrate 10.

[55] Furthermore, a parasitic capacitive component between the capacitive element 115 of the IDT pattern and the ground surface forms a parallel capacitor C_R, and a serial inductor L_R is generated by current existing on the IDT pattern. Thus, the transmission line operates as a CRLH transmission line structure entirely.

[56] Meanwhile, in the present embodiment, it has been illustrated that the two substrates 10 are joined together and the inductive element 150 is provided on the junction surface of the two substrates 10. However, unlike the above construction, the transmission line may be constructed in such a manner that three or more substrates 10 are joined together and the inductive element 150 is provided on at least one of plural junction surfaces formed between the substrates 10.

[57] In this case, the number of the inductive element 150 is one or more, and between-respective elements can be electrically connected by connection elements provided on the via holes of the substrate 10.

[58] A construction of a transmission line according to a second embodiment of the present invention will be described below with reference to FIGS. 7 and 8.

[59] The present embodiment basically includes a transmission unit 210, a ground unit 230, and inductive elements 250 as in the first embodiment. The transmission unit 210 includes a capacitive element 215 and a stub 217, which are repeated.

[60] However, in the present embodiment, the inductive element 250 provided between both surfaces of two substrates 40 is not provided on a junction surface of the substrates 40, but is formed to have a predetermined pattern on via holes 43 between the substrates 40.

[61] In other words, as shown in FIG. 7, the substrates 40 have both surfaces penetrated by the via holes 43, and the inductive element 250 are formed in a predetermined pattern on the via holes 43.

[62] The inductive element 250 is not limited to the above pattern shape. FIGS. 7 and 8 illustrate a shape in which the inductive element 250 has a helical element and extends up and down.

[63] The inductive element 250 has one end electrically connected to a stub 217 of the transmission unit 210 and the other end electrically connected to a ground unit 230 formed on a bottom surface of the substrate 40.

[64] Meanwhile, the transmission line can be constructed by combining the first and second embodiments. That is, in the substrate 40 in which a plurality of substrates are joined together, the transmission line can be constructed in such a manner that the inductive element 250 is provided between the junction surfaces of the substrate 40 and each connection element has a helical-shaped inductive element 250.

[65] Although the specific embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

[66] The transmission line having a LH characteristic has been described as an example so far. However, the invention is not limited to the disclosed embodiments, but may be universally applied to transmission lines having various shapes for forming a serial capacitor and a parallel inductor.

Claims

[1] A transmission line, comprising:
a conductive transmission unit formed on one surface of a substrate and adapted to transmit an electrical signal;
a ground unit formed on the other surface of the substrate; and
inductive element formed to have a predetermined pattern between two surfaces of the substrate and adapted to interconnect the transmission unit and the ground unit so as to ground the transmission unit.

[2] The transmission line of claim 1, wherein the transmission unit comprises one or more capacitive elements disposed at predetermined intervals in the length direction.

[3] The transmission line of claim 2, wherein the capacitive element has an IDT (interdigital)-shaped pattern.

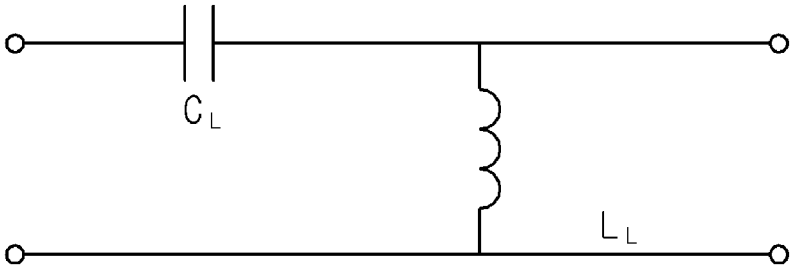
[4] The transmission line of any one of claims 1 to 3, wherein the inductive element includes a helical element extending upwardly and downwardly between the surfaces of the substrate.

[5] The transmission line of any one of claims 1 to 3, wherein:
the substrate is formed in plural, and
the inductive element is formed on a junction surface between the plurality of substrates.

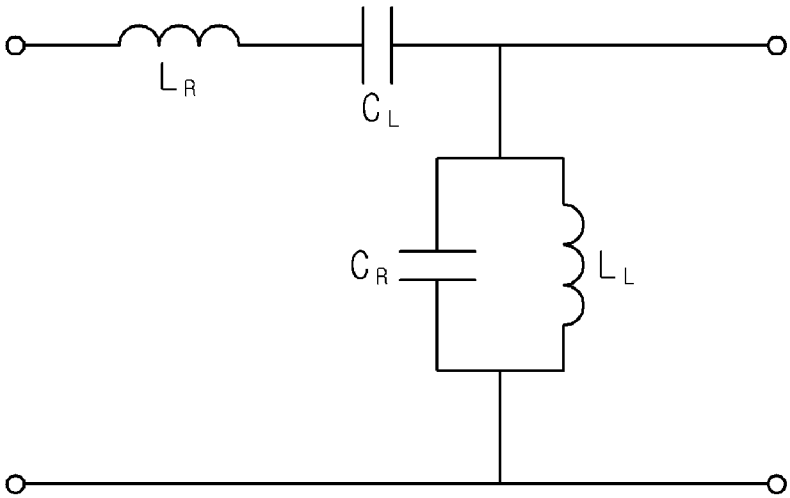
[6] The transmission line of any one of claims 1 to 3, wherein the inductive element comprises a spiral-shaped element.

[7] The transmission line of claim 1, wherein:
the inductive element is connected to the transmission unit or the ground unit by means of conductive connection element, and the connection element has a helical shape.

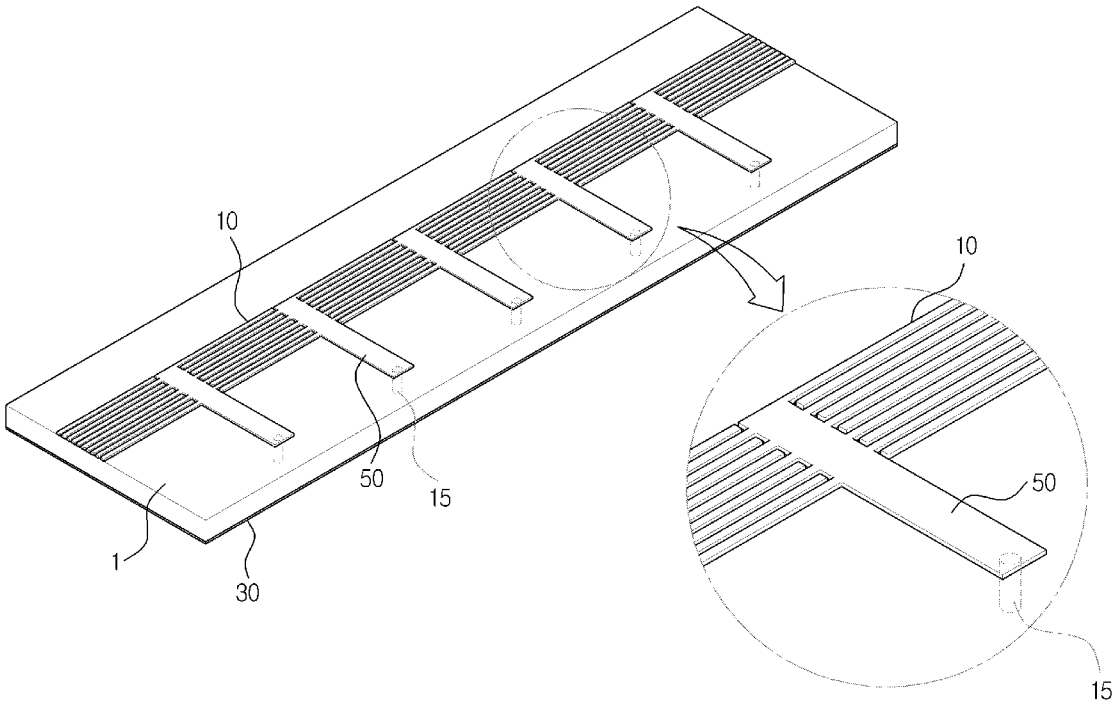
[Fig. 1]



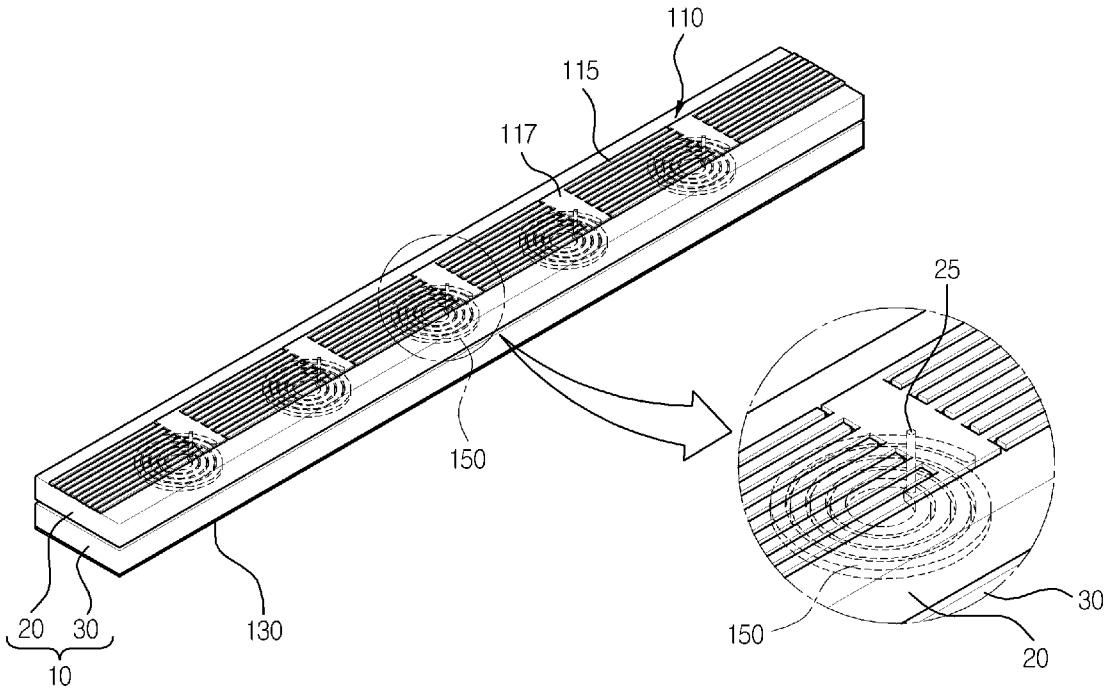
[Fig. 2]



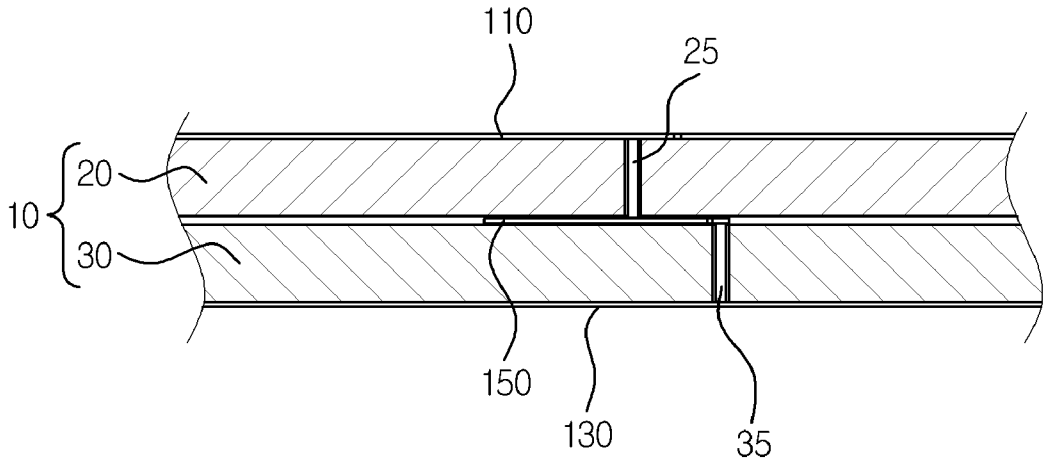
[Fig. 3]



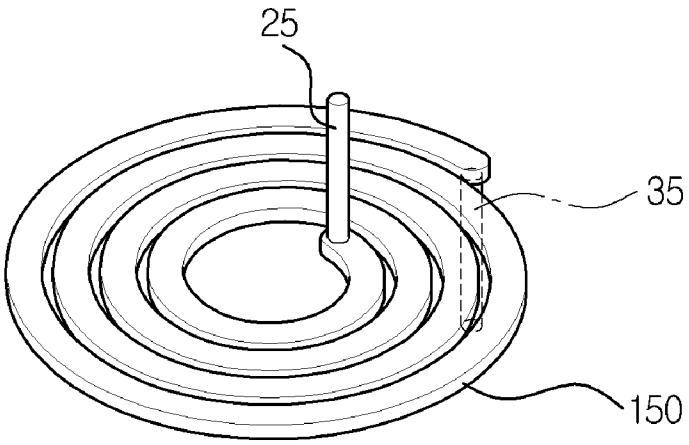
[Fig. 4]



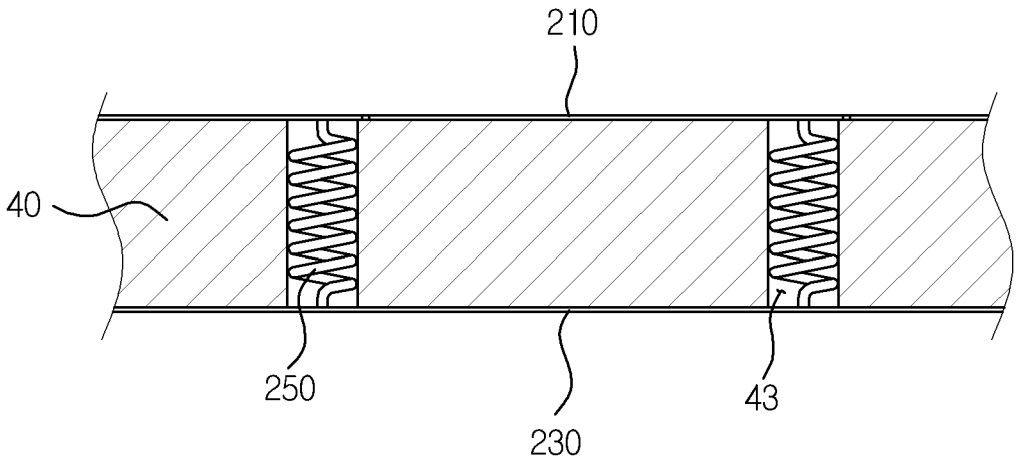
[Fig. 5]



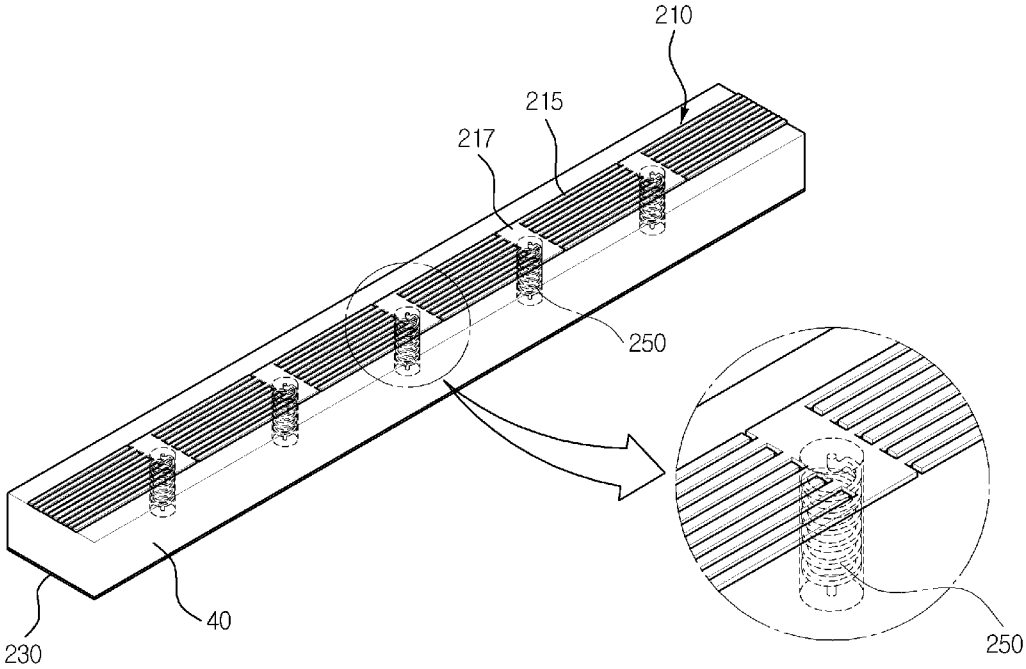
[Fig. 6]



[Fig. 7]



[Fig. 8]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2007/004015

A. CLASSIFICATION OF SUBJECT MATTER

H01P 3/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 8 : H01P 1/18, H01P 1/203, H01P 5/00, H01Q 1/38

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Utility models and applications for Utility models since 1975

Japanese Utility models and applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKIPASS (KIPO internal) "transmission & (meta or metamaterrial) & (inductor or inductance)"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6958729 B1 (Carsten Metz) 25 October 2005. see abstract ; fig.4~5 ; column 4, line 42~column 5, line 60.	1 ~ 7
A	US 2006/0066422 A1 (Tatsuo Itoh et al.) 30 March 2006. see abstract ; fig.2 ; fig.7A ; paragraphs [0011]~[0014] ; paragraph [0020].	1 ~ 7
A	Christophe Caloz, et al., "A novel composite right-/left-handed coupled-line directional coupler with arbitrary coupling level and broad bandwidth", IEEE Transactions on Microwave Theory and Techniques, Vol.52, No.3, March 2004, p.p. 980~992. see abstract ; introduction ; fig.4.	1 ~ 7

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search	Date of mailing of the international search report
29 NOVEMBER 2007 (29.11.2007)	**29 NOVEMBER 2007 (29.11.2007)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2007/004015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US06958729	25.10.2005	US2005225492AA	13.10.2005
US2006066422AA	30.03.2006	None	