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(71) Applicant (*for all designated States except US*): **ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE** [KR/KR]; 161, Gajeong-dong, Yuseong-gu, Daejon 305-350 (KR).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): **YUN, Je-Hoon** [KR/KR]; #206-402 Banseok Maeul 2 Danji, Jijok-dong, Yuseong-gu, Daejon 305-330 (KR).

(74) Agent: **SHINSUNG PATENT FIRM**; ID Tower #601,, Jungdaero 105 (99-7 Garak-dong),, Songpa-gu,, Seoul 138-805 (KR).

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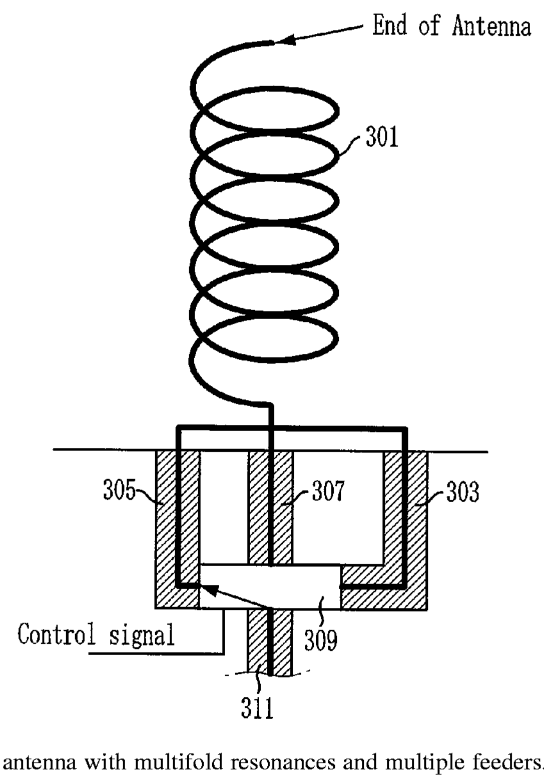
(54) Title: A SMALL ANTENNA WITH MULTIFOLD RESONANCES AND MULTIPLE FEEDERS



(57) Abstract: Provided is a small antenna with multifold resonances and multiple feeders. The antenna includes an antenna element; a plurality of feeders for supplying power to the antenna element; and a feed switch for selectively connecting one of the feeders with the antenna element to supply power to the antenna element, wherein the feeders are disposed to vary a total length of the antenna element.

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DESCRIPTION

A SMALL ANTENNA WITH MULTIFOLD RESONANCES AND MULTIPLE FEEDERS

TECHNICAL FIELD

The present invention relates to a small antenna with multifold resonances and multiple feeders; and, more particularly, to a small antenna with multifold resonances and multiple feeders, which is capable of multi-band transmission/reception by installing, within one antenna, a plurality of feeders that can vary the total length of the antenna (which is a length from a feed point up to an antenna end).

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BACKGROUND ART

In a wireless communication field, a miniaturization technology for, e.g., a terminal, a relay and a base station is drawing much attention. Particularly, an antenna miniaturization technology for making a protruding portion of an antenna small or installing an antenna within a portable terminal is being developed to improve portability.

That is, development of a small antenna is demanded over the entire wireless communications fields such as a radio-frequency identification (RFID) reader, a transponder, a mobile Internet terminal, a terrestrial digital multimedia broadcasting (T-DMB) terminal, a digital video broadcasting-handheld (DVB-H) terminal, a mobile relay, a home network terminal for wireless control, a wireless access notebook, a communication or multi-purpose satellite.

However, an antenna generally has a narrowband characteristic, and its efficiency is deteriorated if the antenna is miniaturized. That is, if the antenna is miniaturized, an antenna radiation pattern has an omni-directional characteristic, and an antenna gain decreases. Also, the input resistance of the antenna significantly decreases and reactance significantly increases, thereby reducing a bandwidth of the antenna to a great extent.

Fig. 1 is a view illustrating an example of a maximum radius of an antenna. In Fig. 1, a maximum radius 1-1 of a monopole antenna and a maximum radius 1-2 of a dipole antenna are illustrated.

Referring to Fig. 1, the maximum bandwidth BWmax that can be obtained from an antenna having the maximum radius a, which refers to a distance from a point where a ground meets an antenna element (which is a conductor) up to an end of an antenna element in the case of the monopole antenna, and a distance from a feed point up to an end of the antenna element in the case of the dipole antenna, is expressed as the following Equation:

$$BW\max = 2/[(ka)^{-1} + (ka)^{-3}]$$

where k denotes a wave number, which is 2p/l (in which l is a wavelength). For example, in the case of an antenna having the maximum radius of l/20, e.g., a T-DMB terminal antenna having the maximum radius of about 9 cm, the maximum bandwidth without loss is about 5.5%. However, a frequency band being used for a T-DMB in Korea ranges from 174 MHz to 216 MHZ, and thus a bandwidth of about 22 % is required. For this reason, it is difficult to receive a T-DMB signal with one small antenna, and thus it is required to develop a small antennal having a wideband characteristic by generating a plurality of resonant frequencies is required.

Fig. 2 is a view illustrating a T-DMB frequency bandwidth and a channel bandwidth that are currently being used.

As shown in Fig. 2, the T-DMB frequency bandwidth includes a plurality of channel bandwidths. Although the T-DMB frequency bandwidth is 42 MHz, one channel bandwidth is 1.536 MHz, which is very narrow. Thus, when reception is made using one channel, a channel bandwidth of another channel is not used. For this reason, wideband reception that allows the use of multiple channels can be performed using one small antenna.

That is, multi-channel reception in one small antenna can be performed. Thus, wideband reception using the small antenna can be achieved. However, the bandwidth of the small antenna must be wider than a channel bandwidth of Fig. 2.

As conventional efforts to obtain a wideband characteristic in a small antenna, a loss of an antenna element is caused, or a thick or parasitic element is used.

However, the loss of the antenna element causes antenna efficiency to degrade. Also, the thick element cannot fundamentally overcome a limited bandwidth resulting from miniaturization of an antenna. The parasitic element also limitedly improves the bandwidth.

Thus, a small antenna allowing wideband transmission and reception, that is, multifold resonances while maintaining antenna efficiency is demanded.

DISCLOSURE

TECHNICAL PROBLEM

An embodiment of the present invention is directed to providing a small antenna that allows multiband, i.e., wideband transmission/reception by independently generating multifold resonances, using a plurality of feeders.

TECHNICAL SOLUTION

In accordance with an aspect of the present invention, there is provided an antenna including: an antenna element; a plurality of feeders for supplying power to the antenna element; and a feed switch for selectively connecting one of the feeders with the antenna element to supply power to the antenna element, wherein the feeders are disposed to vary a total length of the antenna element.

ADVANTAGEOUS EFFECTS

The present invention provides a small antenna with a plurality of feeders capable of independently generating multifold resonances. Therefore, multiband transmission/reception, i.e., wideband transmission/reception, can be performed even with one antenna.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates a maximum radius of an antenna.

Fig. 2 illustrates a terrestrial-digital multimedia broadcasting (T-DMB) frequency bandwidth and a T-DMB channel bandwidth that are currently being used.

Fig. 3 shows a small helical antenna with multifold resonances and multiple feeders in accordance with an embodiment of the present invention.

Fig. 4 describes a small helical antenna with multifold resonances and multiple feeders in accordance with an embodiment of the present invention.

Fig. 5 is a graph showing respective S11 parameters for feeders of the small helical antenna of Figs. 3 and 4.

Fig. 6 illustrates a small planar inverted-F antenna (PIFA) with multifold resonances and multiple feeders in accordance with an embodiment of the present invention.

Fig. 7 is a graph showing respective S11 parameters for feeders of the small PIFA of Fig. 6.

Fig. 8 illustrates a small meander-type antenna with multifold resonances and multiple feeders in accordance with an embodiment of the present invention.

Fig. 9 describes a small spring loop antenna with multifold resonances and multiple feeders in accordance with an embodiment of the present invention.

Fig. 10 illustrates the small spring loop antenna with multifold resonances and multiple feeders of Fig. 9 in accordance with another embodiment of the present invention.

Fig. 11 shows a small spring loop antenna with multifold resonances and multiple feeders in accordance with yet another embodiment of the present invention.

BEST MODE FOR THE INVENTION

The advantages, features and aspects of the invention will become apparent from the following description of the embodiments with reference to the accompanying drawings, which is set forth hereinafter. The specific embodiments of the present invention will be described in detail hereinafter with reference to the attached drawings.

Fig. 3 shows a small helical antenna with multifold resonances and multiple feeders in accordance with an embodiment of the present invention, which illustrates a one-branch-point structure.

Referring to Fig. 3, the small helical antenna in accordance with an embodiment of the present invention includes a conductor 301, a first feeder 303, a second feeder 305, a third feeder 307, a switch unit 309 and a circuit output unit 311. The circuit output unit 311 is connected to a circuit that is generally realized in antennas, e.g., a structure connected to an RF device such as an amplifier, a mixer, an analog-to-digital (AD) converter. The general circuit includes a ground plane, and can be substituted with a printed circuit board (PCB).

The conductor 301 is an antenna element and is configured to transmit/receive a signal to/from the outside.

The first feeder 303, the second feeder 305 and the third feeder 307 extend from one random branch point to the switch unit 309. A distance from the random one branch point of the conductor 301 to the switch unit 309 varies with the first feeder 303, the second feeder 305 and the third feeder 307.

The switch unit 309 selectively connects the circuit output unit 311 to one of the first feeder 303, the second feeder 305 and the third feeder in response to a control signal sent from the general circuit. As the circuit output unit 311 is connected to one of the first feeder 303, the second feeder 305 and the third feeder 307, the total length of the conductor 301, i.e., a length from a feed point to an antenna end can be varied, also varying a resonant length of the antenna to change.

Three feeders of the first feeder 303, the second feeder 305 and the third feeder 307 are illustrated in Fig. 3. However, for example, four or five feeders may be randomly installed according to embodiments, provided that the total length of the conductor 301 can be varied upon selection of the feeder.

The switch unit 309 must be connected to a ground plane included in the general circuit, so that an influence of a switch and a switch control signal to a resonant frequency can be minimized. In a monopole antenna, the ground plane allows resonance of the antenna to occur at 1/4 wavelength, thereby contributing to reducing an antenna size.

As for the switch unit 309, one of the feeders 303, 305 and 307 may be selectively connected with the circuit output unit 311 by using one switch, or one switch may be installed for each of the feeders 303, 305 and 307 to selectively connect one of the feeders 303, 305 and 307 with the circuit output unit 311. If a switch is installed for each feeder, an electrical length change can be accurately controlled, so that a resonant frequency can be precisely controlled.

The switch unit 309 automatically controls the switch by using resonant frequency information of an LC switch, or local oscillation frequency information selected by an intermediate frequency converter and applied to a mixer. A switching direction that maximizes a signal to noise ratio of a radio frequency (RF) signal or an intermediate frequency by a feedback operation can be selected.

If the switch unit 309 is connected simultaneously with a plurality of feeders, it can be considered as one antenna, and thus a bandwidth is limited by a maximum bandwidth of a small antenna. Therefore, the circuit output unit 311 in the small antenna in accordance with an embodiment of the present invention is connected to one feeder and disconnected with the rest of the feeders.

The circuit output unit 311 is a feed point and provides power to the conductor part 501 along the connected first feeder 303, the second feeder 305 or the third feeder 307.

Thus, the small antenna having a structure described above can have a small size while operating like a monopole antenna.

Fig. 4 is a view of a small helical antenna with multifold resonances and multiple feeders in accordance with an embodiment of the present invention, illustrating a multi-branch-point structure.

As shown in Fig. 4, the small helical antenna with the multi-branch-point structure of Fig. 4 has the same structure as the small helical antenna, except for the branch point.

The first feeder 303, the second feeder 305 and the third feeder 307 are connected up to the switch unit 309 from respectively different random points of the conductor 301. That is, the first feeder 303, the second feeder 305 and the third feeder 307 is connected up to the switch unit 390 from different points of the conductor 301, respectively.

Thus, distances from the respective points of the conductor 301 connected to the first feeder 303, the second feeder 305 and the third feeder 307 to the switch unit 309 become different from each other.

Referring to Fig. 4, the length of the conductor 301 is the longest when the circuit output unit 311 is connected to the first feeder 303. Thus, the first feeder 303 serves as a feed point implementing the longest resonant length. Also, the second feeder 305 serves as a feed point implementing the intermediate resonant length. When the circuit output unit 311 is connected to the third feeder 307, the length of the conductor 301 is the shortest. Thus, the third feeder 307 serves as a feed point implementing the shortest resonant length.

Accordingly, a resonant frequency is generated in the lowest band when the circuit output unit 311 is connected with the first feeder 303, and generated in the highest band in the case of connection with the third feeder 307.

Since an antenna element of a helical antenna is wound up in the above-described multi-branch-point structure, the feed points are connected to respective points of the antenna element where is wound up, so that change of the total length of the antenna and manufacturing of the antenna can be facilitated.

Fig. 5 is a graph showing respective S11 parameters for the feeders of the small helical antenna of Fig. 3 or 4.

An antenna is a discontinued line and an end thereof is made to resonate at a specific frequency, so that a signal is transmitted to the outside with a specific magnetic-field energy without undergoing total reflection. That is, basically, the antenna is a one-port device having one input port. Thus, the antenna has only a S11 value representing an input reflection coefficient, the S11 value (dB) is minimized at a frequency at which the antenna operates, and signal power input to the antenna is maximally radiated to the outside at the frequency at which the S11 value is the minimum. That is, the best impedance matching is achieved at the point where the S11 value is the minimum.

As shown in Fig. 5, graph A represents a case where the circuit output unit 311 is connected to the first feeder 303, graph B represents a case where the circuit output unit 311 is connected to the second feeder 305, and graph C represents a case where the circuit output unit 311 is connected to the third feeder 307.

The total length of the antenna from the feed point to the antenna end is the longest in the case of the connection with the first feeder 303, and is the shortest in the case of the connection with the second feeder 307.

Thus, as shown in graph A, the resonant frequency is generated in the lowest band in connection with the first feeder 303. Also, as shown in graph B, the resonant frequency is generated in the intermediate band in connection with the second feeder 305. As shown in graph C, the resonant frequency is generated in the highest band in connection with the third feeder 307.

As described above, a resonant frequency can be varied by using the small helical antennas of Figs. 3 and 4, and thus wideband transmission/reception can be achieved.

Fig. 6 is a view showing a small PIFA antenna with multifold resonances and multiple feeders in accordance with an embodiment of the present invention.

Referring to Fig. 6, the small PIFA antenna in accordance with this embodiment includes a conductor 601, a first feeder 603, a second feeder 605, a third feeder 607, a switch unit 609, a circuit output unit 611, and a PCB edge board (not shown). The PCB edge board (not shown) includes a circuit that is generally implemented in an antenna, e.g., a structure connected to an RF device, such as an amplifier, a mixer and an AD converter, and includes a ground plate 615. In general, the ground plate 615 is placed at a rear surface of the antenna.

The conductor 601 is an antenna element and serves to transmit/receive a signal to/from the outside, and is installed on a dielectric substance, not the ground plate 615 at the rear surface of the antenna.

Since a PIFA antenna is realized in general by bending or branching the conductor 601, the PIFA antenna shows a narrowband characteristic. Therefore, as shown in Fig. 6, a plurality of feeders 603, 605 and 607 are installed and controlled by using the switch unit 609, so that a PIFA antenna capable of wideband transmission/reception can be implemented.

The first feeder 603, the second feeder 605 and the third feeder 607 connect the circuit output unit 611 with the conductor 601, and are installed such that they can vary the total length of the conductor 601.

The switch unit 609 serves in the same manner as the switch unit 309 of Fig. 3. Accordingly, the switch unit 609 connects the circuit output unit 611 with one of the first feeder 603, the second feeder 605 and the third feeder 607, and e.g., four or five feeders may be randomly installed in accordance with embodiments.

The switch unit 609 may selectively connect one of the feeders 603, 605 and 607 with the circuit output unit 611 by using one switch. Alternatively, one switch may be installed for each of the feeders 603, 605 and 607 to selectively connect one of the feeders 303, 305 and 307 with the circuit output unit 611.

The switch unit 609 is connected with a ground plane included in a general circuit, and a control signal of the switch unit 609 for selection of one feeder can be controlled automatically or manually.

The circuit output unit 611 is a feed point and supplies power from the PCB edge board (not shown) along the connected first, second or third feeder 603, 605 or 607.

As described above, the small PIFA antenna has advantages of high space utilization because of easy access of a feed point to the center of the PCB edge board (not shown).

Fig. 7 is a graph showing respective S11 parameters for the feeders of the small PIFA antenna of Fig. 6.

Referring to Fig. 7, graph D represents the case where the circuit output unit 611 is connected with the first feeder 603, graph E represents the case where the circuit output unit 611 is connected with the second feeder 605, and graph F represents the case where the circuit output unit 611 is connected to the third feeder 607.

The total length of the antenna, i.e., a length from the feed point up to an antenna end is the longest in the case of the connection with the first feeder 603, and is the shortest in the case of the connection with the third feeder 607.

Thus, a resonant frequency is generated in the lowest band in connection with the first feeder 603 as shown in graph D, generated in the intermediate band in connection with the second feeder 605 as shown in graph E, and generated in the highest band in connection with the third feeder as shown in graph F.

By using the aforementioned characteristic, an antenna that is used for, e.g., a wireless communication terminal, a relay or an access point (AP) can be implemented in a transmission/reception environment that includes a narrowband channel and does not use one channel while using another channel.

Fig. 8 shows a small meander-type antenna with multifold resonances and multiple feeders in accordance with an embodiment of the present invention. The meander-type antenna refers to an antenna including a bent conductor, i.e., a bent antenna element.

As shown in Fig. 8, the small meander-type antenna in accordance with this embodiment includes a conductor 801, a first feeder 803, a second feeder 805, a third feeder 807, a switch unit 809 and a circuit output unit 811. The circuit output unit 811 is connected to a general circuit which is generally implemented in an antenna, e.g., a structure connected to an RF device, such as an amplifier, a mixer and an RF device). The general circuit includes a ground plane, and can be substituted with a printed circuit board (PCB).

The conductor 801 is an antenna element, serves to transmit/receive a signal to/from the outside and is installed on a dielectric substance.

The first feeder 803, the second feeder 805 and the third feeder 807 connect the conductor 801 with the circuit output unit 811, and are installed such that the total length of the conductor 801 can vary with each of the feeders 803, 805 and 807.

The switch unit 809 serves in the same manner as the switch unit 309 of Fig. 3. Thus, the switch unit 809 connects the circuit output unit 811 with one of the first feeder 803, the second feeder 805 and the third feeder 807, and, e.g., four or more feeders can be randomly installed in accordance with embodiments.

The switch unit 809 may selectively connect one of the feeder 803, 805 and 807 with the circuit output unit 811 by using one switch. Alternatively, one switch may be installed for each of the feeders 803, 805 and 807 to selectively connect one of the feeder 803, 805 and 807 with the circuit output unit 811.

Also, the switch unit 809 is connected to a ground plane included in a general circuit, and a control signal of the switch unit 809 for selection of one feeder can be controlled automatically or manually.

The circuit output unit 811 is a feed point, and supplies power to the conductor 801 along the connected first, second or third feeder 803, 805 or 807.

As in the graphs of Figs. 5 and 7, the total length of the small meander-type antenna of Fig. 8 is the longest when the circuit output unit 811 is connected with the first feeder 803, and is the shortest when the circuit output unit 811 is connected with the third feeder 807.

A resonant frequency is generated in the lowest band in the case of the connection with the first feeder 803, generated in the intermediate band in the case of the connection with the second feeder 805, and generated in the highest band in the case of the connection with the third feeder 807.

Fig. 9 is a view of a small spring loop antenna with multifold resonances and multiple feeders in accordance with an embodiment of the present invention.

As shown in Fig. 9, the small spring loop antenna of Fig. 9 includes a first feeder 901, a second feeder 903, a switch unit 905, a circuit output unit 907, a PCB edge board 909 and a spring conductor 911, and is installed inside an edge of a case of a portable terminal.

The switch unit 905 serves in the same manner as the switch unit 309 of Fig. 3.

Using the same principle described with reference to Figs. 3 and 4, the switch unit 905 connects the circuit output unit 907 with one of the first feeder 901 and the second feeder 903 in response to a control signal sent from the PCB edge board 909, which is a general circuit.

The first feeder 901 and the second feeder 903 connect the switch unit 905 with the outside of the spring type conductor 911. Distances from respective feed points of the feeder 901 to an end of the spring type conductor 911 are different from each other.

The length of the spring type conductor 911 is the longest when the circuit output unit 907 is connected with the first feeder 901, and thus a resonant frequency is generated in a low band. The length of the spring type conductor 911 is the shortest when the circuit output unit 907 is connected with the second feeder 903, and thus the resonant frequency is generated in the highest band.

Fig. 10 is a view of a small spring loop antenna with multifold resonances and multiple feeders of Fig. 9 in accordance with another embodiment of the present invention.

As shown in Fig. 10, the small spring loop antenna of Fig. 10 includes a first feeder 901, a second feeder 903, a switch unit 905, a circuit output unit 907, a PCB edge board 909, a spring conductor 911, a dielectric substance 1001 and a case connector 1003. Unlike Fig. 9, the second feeder 903 of Fig 10 is connected to a random point within the spring conductor 911 to change the total length of the antenna.

The spring conductor 911 is installed in the dielectric substance 1001 having elasticity and extensibility, e.g., rubber. Thus, if an antenna is installed inside an edge of the terminal case, the antenna can be fixed or implemented in the random shape.

The case connector 1003 is used for connection with a case. When the antenna is installed between the case connector 1003 and a terminal case, the antenna can be easily installed without changing an electrical characteristic thereof.

Fig. 11 is a view of a small spring loop antenna with multifold resonances and multiple feeders in accordance with yet another embodiment of the present invention, illustrating an assembly type manufacturing structure.

As shown in Fig. 11, a first feeder 11-1, a second feeder 11-2, a first conductor 11-3, and a second conductor 11-4 are separately manufactured. That is, for easy manufacturing and mass production, the feeders 11-1 and 11-2 and the conductors 11-3 and 11-4 are separately manufactured and then connected together.

To connect the feeders 11-1 and 11-2 and the conductors 11-3 and 11-4 with each other, conductor screws of e.g., copper, silver, bronze, brass, or aluminum are installed at both ends of each of the feeders 11-1 and 11-2 and the conductors 11-3 and 11-4. Accordingly, a plurality of conductors or the feeders and the conductors are connected with each other.

The first feeder 11-1 and the second feeder 11-2 are installed, connected with a spring conducting wire within a dielectric substance, e.g., Teflon and polyvinyl chloride (PVC), and thus connect random points of the spring conducting wire within the dielectric substance to feed points to vary the length of the conducting wire. Also, the spring conducting wire is wound up in the dielectric substance and then covered with an outer cover, thereby minimizing electric discharge caused by contact.

The first feeder 11-1 includes three antenna input/output (I/O) lines, and one of those three lines is installed on a ground plane GND. Thus, the first feeder 11-1 can have two different antenna lengths. The second feeder 11-2 includes four antennas, and one of those four antennas is installed on a ground plane GND. Thus, the second feeder 112=2 can have three different antenna lengths.

The first conductor 11-3 includes only a spring conducting wire, and screws are installed at both ends of the first conductor 11-3, so that it can be used in connection with a feeder or a plurality of other conductors.

The second conductor 11-4 includes a dielectric substance and a spring conducting line wound inside the dielectric substance, and screws are installed at both ends thereof, so that it can be used in connection with a feeder or a plurality of other conductors. Also, the spring conducting wire is wound up in the dielectric substance and covered with an outer cover, thereby minimizing electric discharge caused by contact.

The small antenna using a plurality of feeders illustrated in Figs. 3 to 11 in accordance with embodiments of the present invention is applicable to an inverted-F antenna such as a planar inverted-F antenna (PIFA), a meander-type antenna, a helical antenna and a spring loop antenna. The small antenna in accordance with embodiments of the present invention is also applicable to a small antenna of 1/4 wavelength or less, such as a spiral top loaded monopole antenna (STLA), a capacitor-plate antenna, and a multi-element top-loaded monopole antenna.

As described above, the technology of the present invention can be realized as a program and stored in a computer-readable recording medium, such as CD-ROM, RAM, ROM, floppy disk, hard disk and magneto-optical disk. Since the process can be easily implemented by those skilled in the art of the present invention, further description will not be provided herein.

While the present invention has been described with respect to certain preferred embodiments, it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the scope of the invention as defined in the following claims.

INDUSTRIAL APPLICABILITY

A small antenna with multifold resonances and multiple feeders capable of multiband transmission/reception, i.e., wideband transmission/reception can be implemented.

WHAT IS CLAIMED IS:

1. An antenna comprising:

an antenna element;

a plurality of feeders for supplying power to the antenna element; and

a feed switch for selectively connecting one of the feeders with the antenna element to supply power to the antenna element,

wherein the feeders are disposed to vary a total length of the antenna element.

2. The antenna of claim 1, wherein the antenna has a maximum radius of 1/4 wavelength or less.

3. The antenna of claim 1, wherein the antenna element is a planar inverted-F antenna (PIFA) element.

4. The antenna of claim 1, wherein the antenna element is a meander-type antenna element.

5. The antenna of claim 1, wherein the antenna element is a helical antenna element.

6. The antenna of claim 1, wherein the antenna element is a spring-type loop antenna element.

7. The antenna of claim 1, wherein the antenna element is a spiral top-loaded monopole antenna (STLA) element.

8. The antenna of claim 1, wherein the antenna element is a capacitor-plate antenna element.

9. The antenna of claim 1, wherein the antenna

element is a multi-element top-loaded monopole antenna element.

10. The antenna of claim 1, wherein the antenna element is an inverted-F antenna element.

FIG. 1

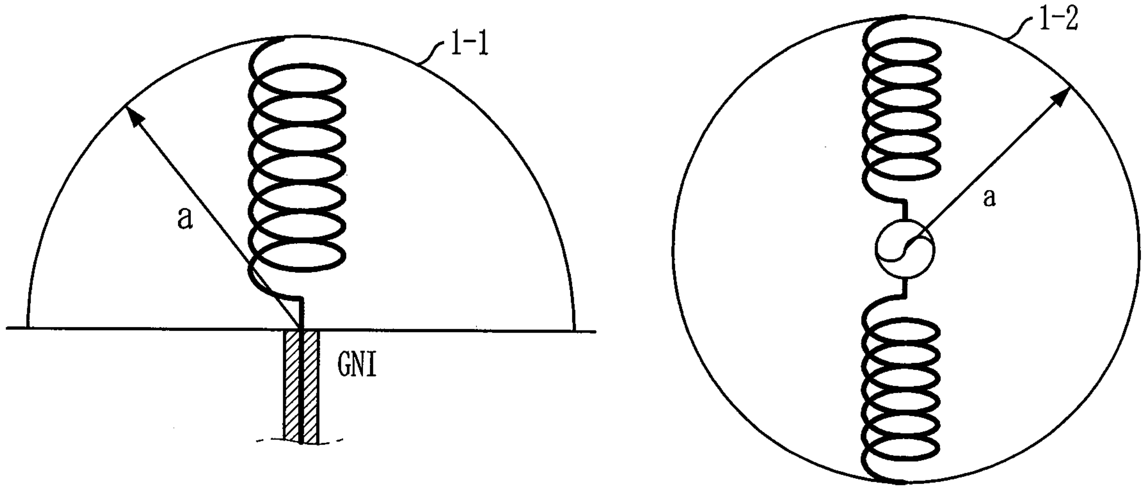

1-1
a
GNI
1-2
a

FIG. 2

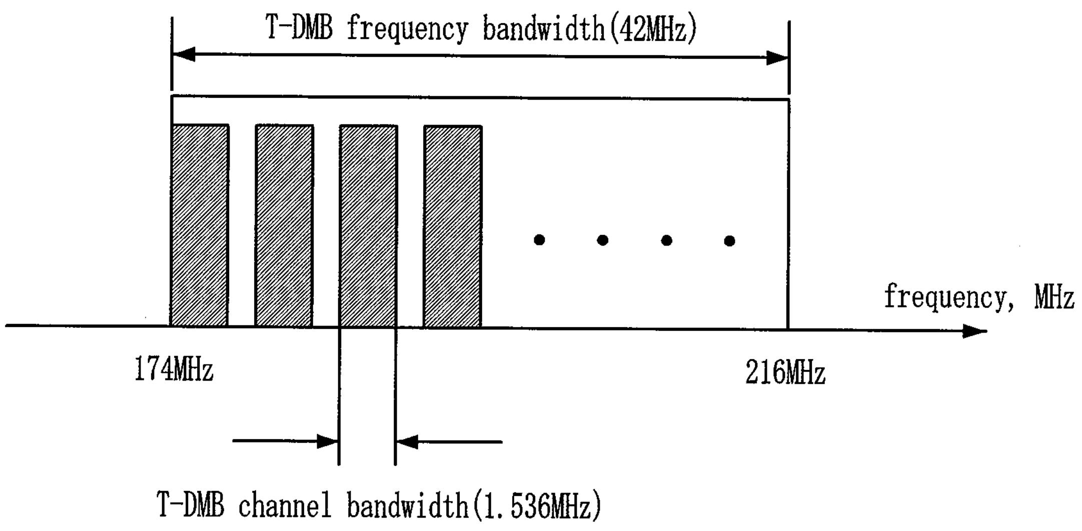

T-DMB frequency bandwidth(42MHz)
frequency, MHz
174MHz
216MHz
T-DMB channel bandwidth(1.536MHz)

FIG. 3

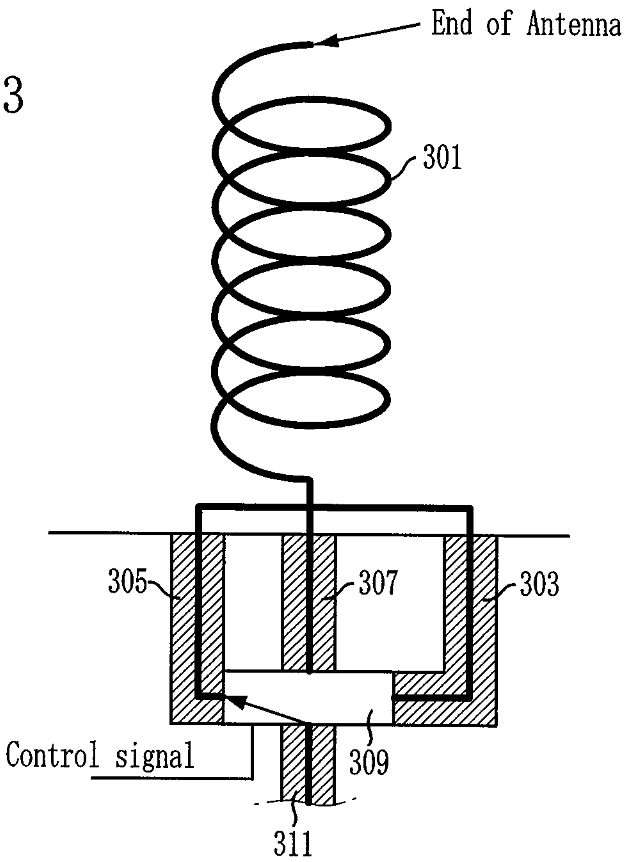

End of Antenna
301
305
307
303
Control signal
309
311

FIG. 4

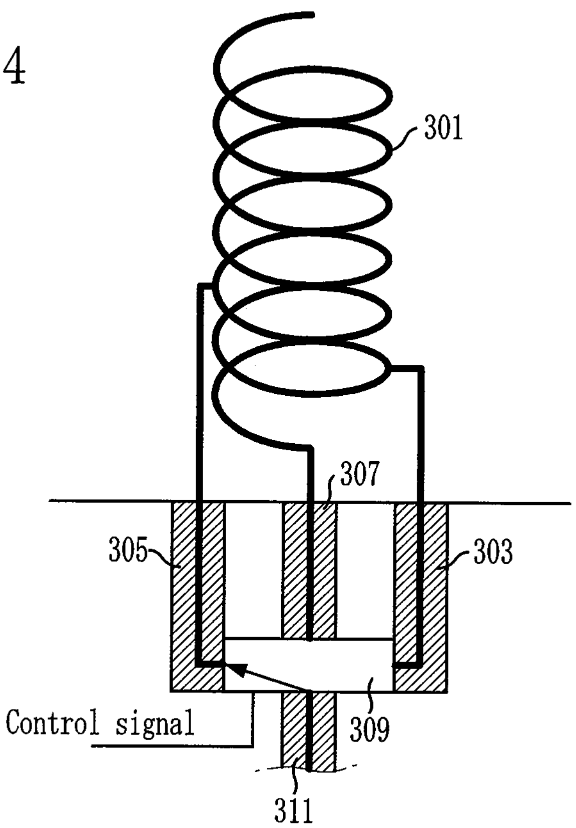

301
307
305
303
Control signal
309
311

FIG. 5

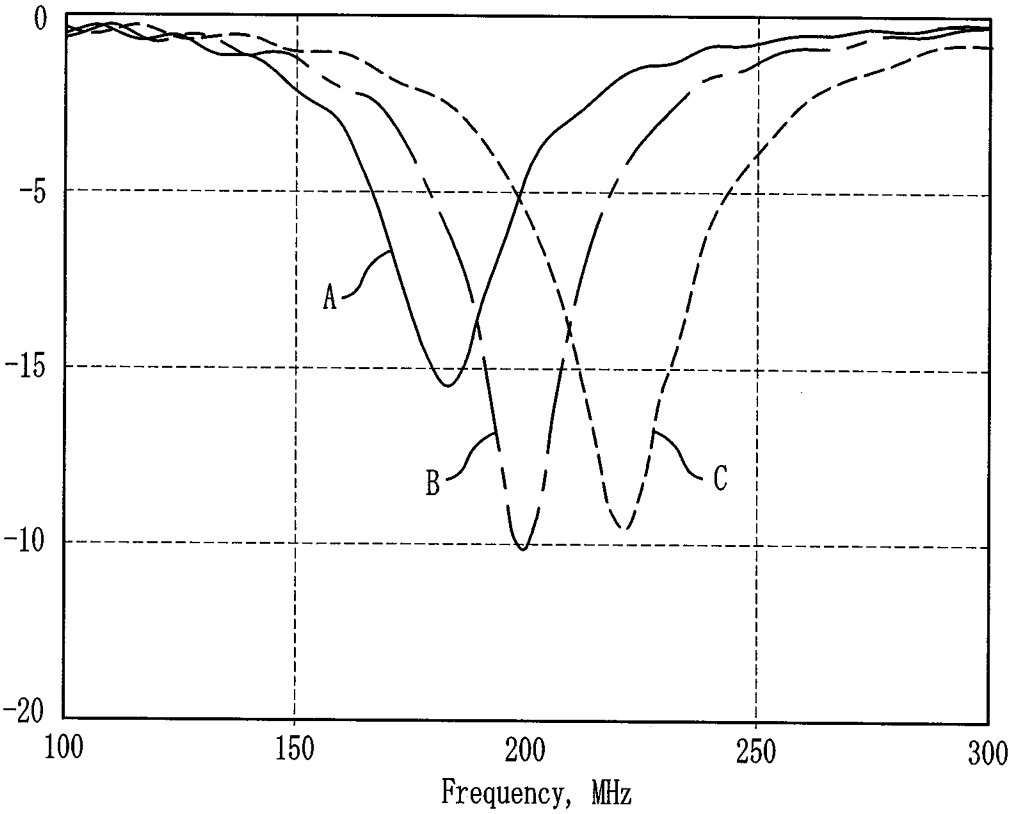

0
-5
-15
-10
-20
100
150
200
250
300
Frequency, MHz
A
B
C

FIG. 6

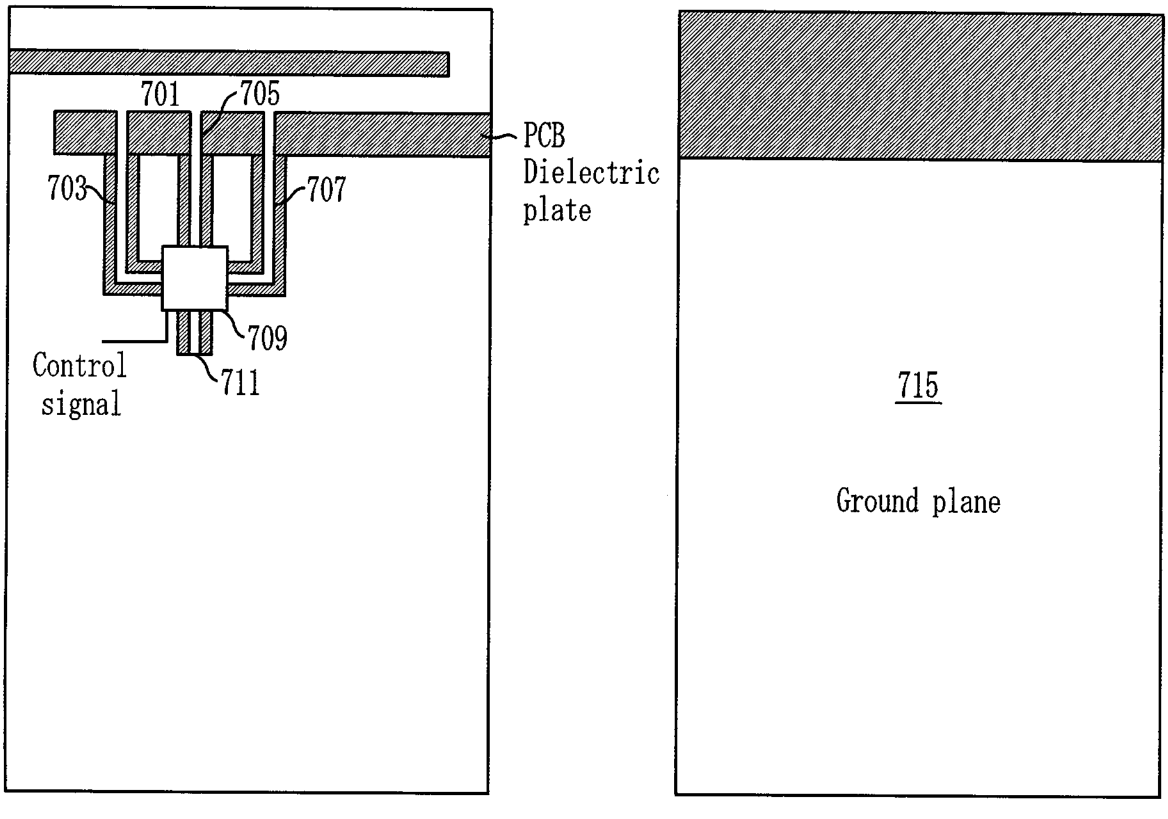

701
705
703
707
PCB
Dielectric
plate
709
Control
signal
711
715
Ground plane

FIG. 7

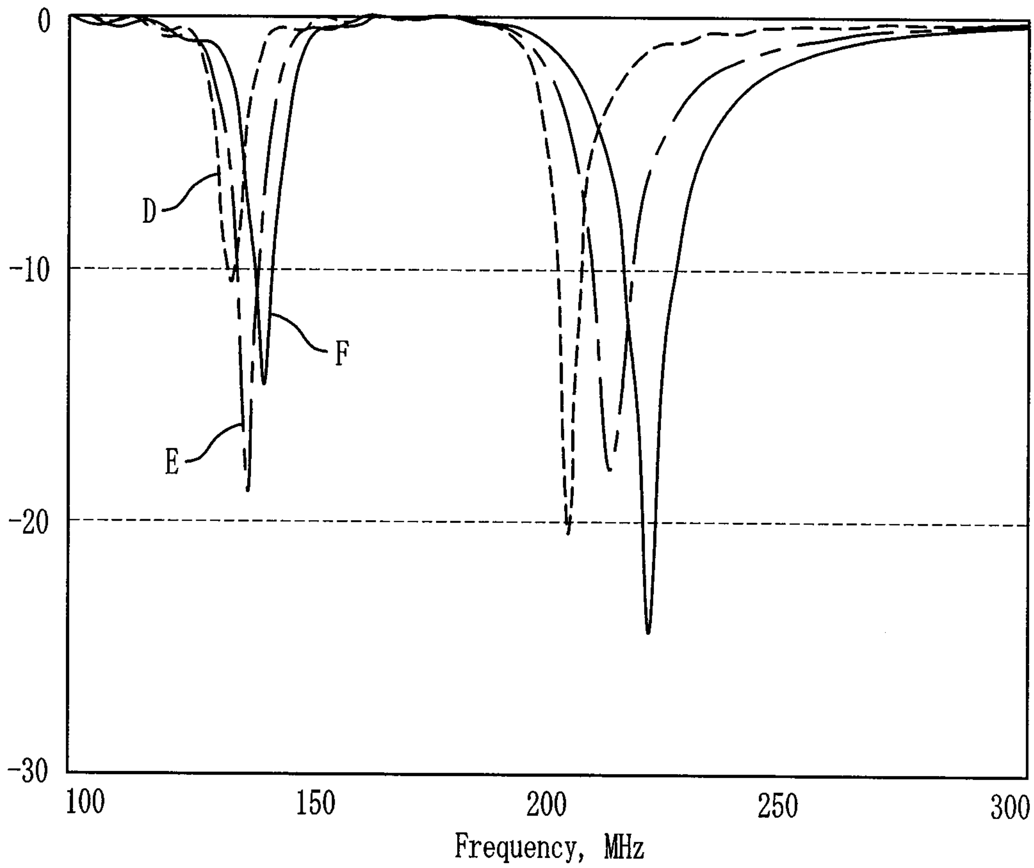

0
-10
-20
-30
D
E
F
100
150
200
250
300
Frequency, MHz

FIG. 8

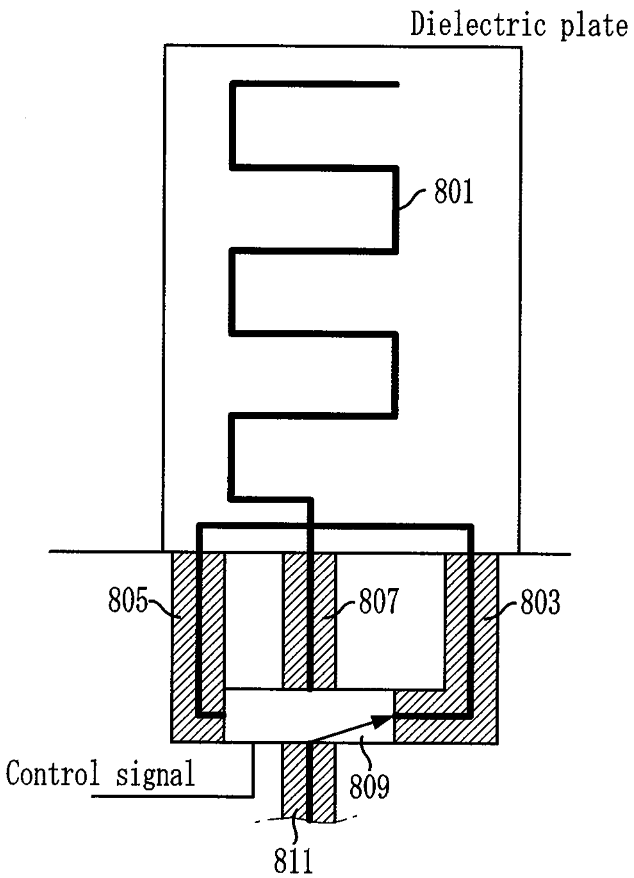

Dielectric plate
801
805
807
803
Control signal
809
811

FIG. 9

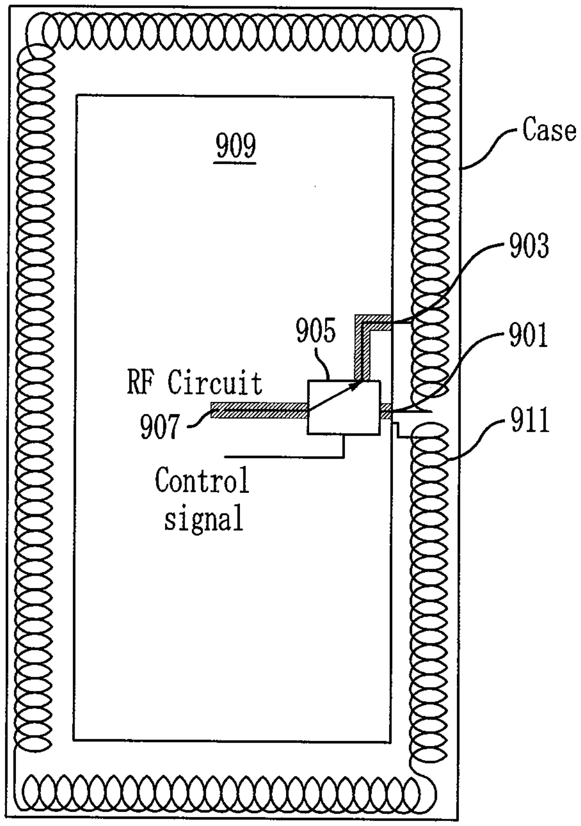

909
Case
903
905
901
RF Circuit
907
911
Control
signal

FIG. 10

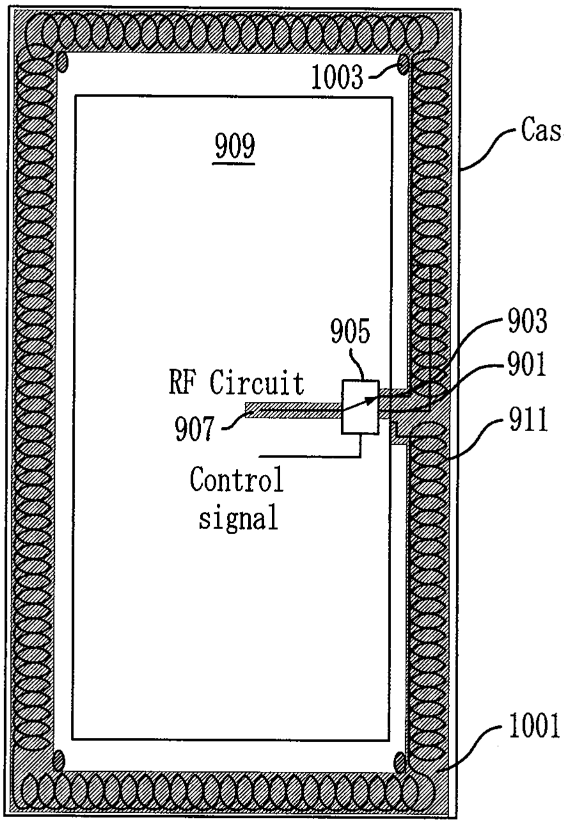
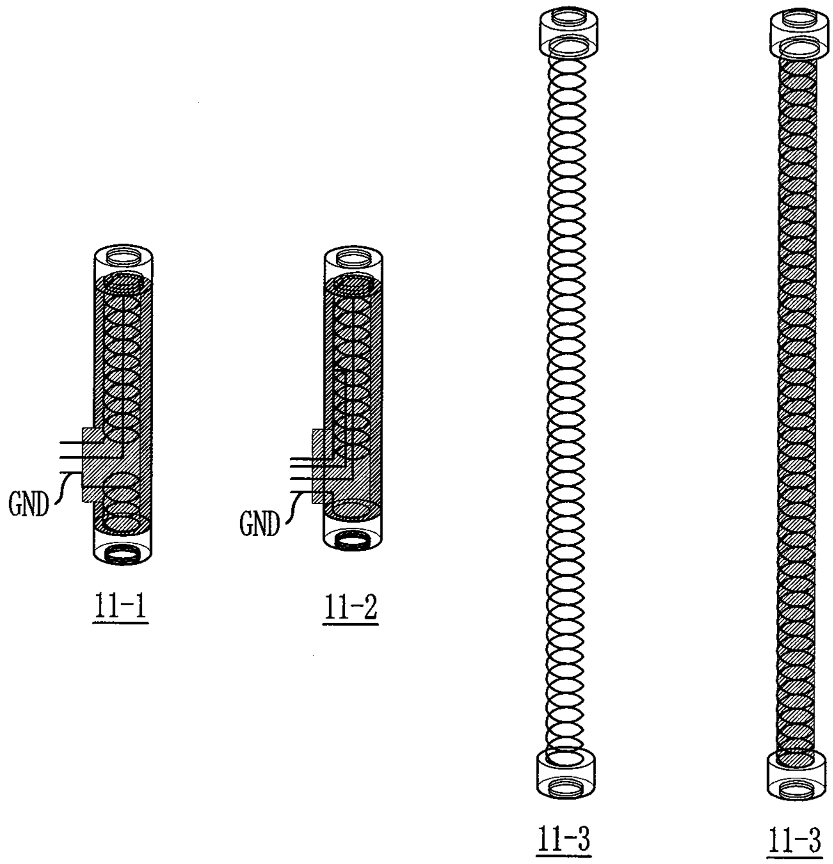

1003
909
Case
905
903
901
RF Circuit
907
911
Control
signal
1001

FIG. 11



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2007/005301

A. CLASSIFICATION OF SUBJECT MATTER

H01Q 9/30(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: H01Q

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) "antenna", "feed", "length", "plural", "multi", "broad"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2005-0162328 A1 (KOHEI MORI) 28 July 2005 See claims 1-3, paragraphs [0075]-[0077], figure 10	1-10
A	US 7050018 B2 (JAMES GRAHAM WEIT) 23 May 2006 See claim 1, column 3, line 58 - column 4, line 6, figure 1	1-10
A	JP 2005-005780 A (HOUKOU ELECTRIC CO., LTD.) 6 January 2005 See claim 1, paragraph [0036], figures 1 and 2	1-10
A	US 6069587 A (JONATHAN LYNCH et al) 30 May 2000 See claim 1, column 3, line 41 - column 4, line 34, figure 1	1-10

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

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 JANUARY 2008 (23.01.2008)	**23 JANUARY 2008 (23.01.2008)**

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Korean Intellectual Property Office
920 Dunsan-dong, Seo-gu, Daejeon 302-701,
Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

JEON, CHANG IK

Telephone No. 82-42-481-8261

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2007/005301

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005-0162328 A1	28.07.2005	US 7132992 B2	07.11.2006
US 7050018 B2	23.05.2006	US 2006-050006 A1	09.03.2006
JP 2005-005780 A	06.01.2005	CN 1574456 A	02.02.2005
		US 2004-0246188 A1	09.12.2004
		US 6985114 B2	10.01.2006
US 6069587 A	30.03.2000	None	