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(12) # EUROPEAN PATENT APPLICATION

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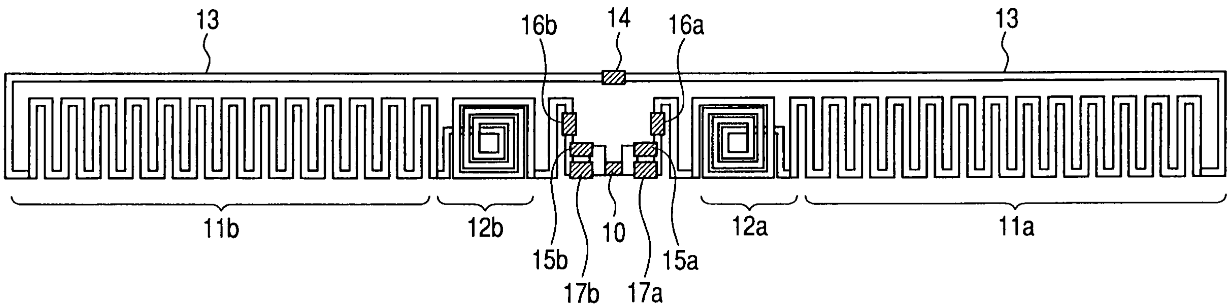
(54) **Antenna device**

(57) A dipole compact tunable antenna device has a radial conductor formed of a meander line (11a) disposed on the right side of a power supply portion (10), and a radial conductor formed of a meander line (11b) disposed on the left side. A conductive bridge (13) is provided between the end portions of the meander lines (11a, 11b), a resistor (14) is connected in the middle of the bridge (13). A load (resistor 14) is provided at the open end portions (end portions of meander lines 11a, 11b) of the radial conductors through the bridge (13), thereby changing.the end portions of the radial conductors from the open (impedance: infinity) state to a low impedance state.

FIG. 1



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Description

BACKGROUND

1. Technical Field

[0001] The present invention relates to an antenna device having a wide-band antenna characteristic, capable of receiving wide-band broadcasting signals such as terrestrial digital broadcasting by a compact antenna element.

2. Related Art

[0002] There is a tunable antenna device varying an operating frequency by controlling bias voltage of a variable capacitance diode, for example, an antenna device disclosed in Japanese Patent Application Laid-Open No. 2006-319451. FIG. 7 is a circuit diagram illustrating an antenna device. The antenna device 1 is provided with a loading element 2 having a linear conductive pattern formed on an insulating resin substrate (not shown), an inductor 3 connected between one end of the loading element 2 and a ground, and a frequency control unit 4 connected between the one end of the loading element 2 and the inductor 3. The one end of the loading element 2 is connected to an inductor 5 for setting a resonance frequency of the antenna device 1. The frequency control unit 4 is provided with variable capacitance diodes 6A and 6B, cathodes of which are opposed to each other between the one end of the loading element 2 and the inductor 3, and a capacitance varying unit 7 for varying values of capacitance of the variable capacitance diodes 6A and 6B to the other values by applying bias voltage to a connection point P2 between the variable capacitance diodes 6A and 6B. The capacitance varying unit 7 is provided with an antenna switch 8 for switching a signal path between a transmission signal and a reception signal, and a bias voltage changing unit 9 for changing bias voltage applied to the variable capacitance diodes 6A and 6B. The capacitance varying unit 7 is also provided with block inductors 10 and 11 for preventing high frequency signals flowing in the variable capacitance diodes 6A and 6B from flowing into the ground, a block inductor 12 for preventing high frequency signals flowing in the variable capacitance diodes 6A and 6B from flowing into the bias voltage changing unit 9 by connecting the bias voltage changing unit 9 and the connection point P2 to each other, and a DC block capacitor 13 for removing a direct-current component of the reception signal by connecting the anode of the variable capacitance diode 6B and a power supply point P1.

[0003] The resonance frequency of the antenna device 1 having the above-described configuration is in proportion to $1/(L.C)^{1/2}$, where L is an inductance component caused by electric field of the antenna element and C is a capacitance component caused by the variable capacitance diodes 6A and 6B. Accordingly, it is possible to change the resonance frequency of the antenna device 1 by changing the capacitance of the variable capacitance diodes 6A and 6B with the bias voltage changing unit 9.

[0004] The antenna device 1 covers the band of 100 to 140 MHz. However, the present inventors have developed a compact tunable antenna device capable of receiving wide-band (e.g., UHF band: 470 MHz to 770 MHz) signals such as television broadcasting signals.

[0005] FIG. 8 is a diagram illustrating a configuration of the compact tunable antenna device developed by the inventors.

[0006] The antenna device shown in FIG. 8 is a dipole tunable antenna device. A power supply portion 20 is provided in the middle of the dipole antenna, and meander lines 21a and 21b as radial conductors are disposed on the left and right of the power supply portion 20. Two pairs of variable capacitance diodes (22a, 23a) and (22b, 23b) are connected between the power supply portion 20 and the meander line 21a and between the power supply portion 20 and the meander line 21b, respectively, and pattern inductors 24a and 24b are provided therebetween. Inductors 25a and 25b are power supply inductors. The bias voltage for switching the resonance frequency of the antenna device 1 is applied to the variable capacitance diodes (22a, 23a) and (22b, 23b). As described above, the meander lines 21a and 21b are formed as the radial conductors, thereby reducing the lengthwise size of the radial conductors and also covering the television signal band with the variable capacitance diodes (22a, 23a) and (22b, 23b).

[0007] The tunable antenna device shifts the operating frequency to the high frequency band by reducing the capacitance of the variable capacitance diodes and raising the resonance frequency. When the capacitance of the variable capacitance diodes is reduced, equivalent resonance Q of the antenna is increased and a band width thereof is decreased, thereby deteriorating stability of reception.

[0008] Like the dipole antenna shown in FIG. 8, when the end portions of the radial conductors are open (impedance: infinity), a difference in impedance between the power supply portion and the open end portions of the radial conductors is very large. Accordingly, it is difficult to perform the impedance matching, and the equivalent resonance Q of the antenna is increased. In addition, even in the case of a monopole antenna in which an end portion of the radial conductor is open, there is the same problem.

SUMMARY

[0009] The invention has been made to solve the aforementioned problems, an object of which is to provide an antenna device capable of widening an operating frequency band in the high frequency band in a dipole or monopole compact antenna device, thereby improving stability of reception.

[0010] An antenna device according to the invention includes a power supply portion; a radial conductor, one end of which is connected to the power supply portion and the other end is open; and a resistor connected to the open end of the radial conductor, wherein a closed loop for decreasing impedance of the radial conductor is formed by the power supply portion, the radial conductor, and the resistor.

[0011] With such a configuration, since the resistor is connected to the open end of the radial conductor to form the closed loop for decreasing the impedance of the radial conductor, the impedance of the radial conductor is decreased in the high frequency band in which the operating frequency band is insufficient, thereby decreasing the resonance Q of the antenna. Accordingly, it is possible to widen the operating frequency band in the high frequency band.

[0012] In the antenna device according to the invention, the radial conductor may be formed by first and second radical conductors disposed with the power supply portion therebetween to form a dipole antenna, and the resistor may be connected between the open ends of the first and second radial conductors.

[0013] With such a configuration, since the resistor is connected between the open ends of the first and second radial conductors in the dipole antenna, it is possible to widen the operating frequency band in the high frequency band in the dipole antenna.

[0014] In the antenna device according to the invention, the open ends of the first and second radial conductors may be connected to each other by a conductive bridge, and the bridge may be provided with the resistor. With such a configuration, it is possible to form a closed loop in which the open ends of the first and second radial conductors are connected to each other by the resistor.

[0015] In the antenna device according to the invention, the power supply portion may be connected to the one end of the radial conductor to form a monopole antenna, the resistor may be connected between the open end of the radial conductor and a ground pattern, and the power supply portion and the end portion on the ground side of the resistor may be connected through the ground pattern.

[0016] With such a configuration, since the resistor is connected between the open end of the radial conductor and the ground pattern in the monopole antenna, it is possible to widen the operating frequency band in the high frequency band in the monopole antenna.

[0017] In the antenna device according to the invention, a variable capacitance element may be provided between the power supply portion and the radial conductor, and the antenna device may be a tunable antenna capable of being tuned to a desired frequency by applying bias voltage to the variable capacitance element.

[0018] With such a configuration, since the capacitance of the variable capacitance element is reduced and it is possible to widen the operating frequency band at the time of signal reception in the high frequency band, it is possible to improve stability of reception.

[0019] In the antenna device according to the invention, a capacitor may be connected to the resistor in series.

[0020] With such a configuration, since the capacitance is high impedance and signals are not allowed to pass in the operating frequency band in the low frequency band in which it is not necessary to provide the resistor at the end portions of the radial conductors, the end portion of the radial conductor is open and thus loss of gain is suppressed. On the other hand, in the operating frequency or higher in which it is necessary to provide the resistor at the end portions of the radial conductors, the capacitance is low impedance, and a closed loop is formed in which the resistor is interposed between the power supply portion and the end portions of the radial conductors. Accordingly, it is possible to decrease the resonance Q of the antenna, and thus it is possible to widen the operating frequency band of the high frequency band.

[0021] In the antenna device according to the invention, the radial conductor may be formed in a meander shape. Accordingly, it is possible to make the antenna device compact.

[0022] According to the invention, it is possible to widen an operating frequency band in the high frequency band in a dipole or monopole compact antenna device, thereby improving stability of reception.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023]

FIG. 1 is a diagram illustrating a configuration of an antenna device according to a first embodiment of the invention.

FIG. 2 is an equivalent circuit diagram illustrating a right half of the antenna device according to the first embodiment.

FIG. 3 is a diagram illustrating comparison of characteristics between the antenna device according to the first embodiment and an antenna device shown in FIG. 8.

FIG. 4 is a diagram illustrating a configuration of an antenna device according to a second embodiment of the invention.

FIG. 5 is an equivalent circuit diagram illustrating a right half of the antenna device according to the second embodiment.

FIG. 6 is a diagram illustrating a configuration of an antenna device according to a third embodiment of the invention.

FIG. 7 is a circuit diagram illustrating an antenna device disclosed in Patent Document 1.

FIG. 8 is a diagram illustrating a configuration of a compact tunable antenna device.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0024] Hereinafter, embodiments of the invention will be described in detail with reference to the accompanying drawings.

(First Embodiment)

[0025] FIG. 1 is a diagram illustrating a configuration of an antenna device according to a first embodiment of the invention. A dipole antenna device according to the embodiment includes a radial conductor (first radial conductor) formed of a meander line 11a extending to one side (right side in FIG. 1) of a power supply portion 10, and a radial conductor (second radial conductor) formed of a meander line 11b extending to the other side (left side in FIG. 1). Pattern inductors 12a and 12b formed of spiral patterns are connected between the power supply portion 10 and the meander lines 11a and 11b, respectively. Varactor diodes 15a and 16a that are variable capacitance elements are connected in series between the end portion of the pattern inductor 12a on the power supply portion side and the power supply portion 10. Similarly, varactor diodes 15b and 16b that are variable capacitance elements are connected in series between the end portion of the pattern inductor 12b on the power supply portion side and the power supply portion 10. Electric power is supplied from the power supply portion 10 through power supply inductors 17a and 17b to the left and right radial conductors. A conductive bridge 13 is provided in parallel to the meander lines 11a and 11b, between the end portion (end portion of right radial conductor) of the meander line 11a extending to the right side and the end portion (end portion of left radial conductor) of the meander line 11b extending to the left side. A resistor 14 is provided in the middle of the bridge 13.

[0026] That is, the bridge 13 is interposed between the open end portions (end portions of meander lines 11a and 11b) of the radial conductors, and is provided with the load (resistor 14), and thus the open ends of the radial conductors are changed from the open (impedance: infinity) state to the low impedance state. In this example, the interval between the bridge 13 and the meander lines 11a and 11b is set to 0.5 mm, but may be modified depending on the size of the antenna. In the embodiment, the resistor 14 is provided in the vicinity of the power supply portion 10 as the middle of the antenna, but the position of the resistor 14 is not limited to the middle of the antenna.

[0027] FIG. 2 is an equivalent circuit diagram illustrating a right half of the antenna device according to the embodiment. The one end of the conductive bridge 13 is connected to the end portion of the meander line 11a. In FIG. 2, capacitances of the varactor diodes 15a and 16a are represented by C_{T1} and C_{T2}, an inductance of the pattern inductor 12a is represented by Lm, a capacitance component of the bridge 13 is represented by Cr, and an inductance component of the bridge 13 is represented by Lr. Tuning voltage is applied from a bias circuit (not shown) to each of cathodes of the varactor diodes 15a and 16a. A left half of the antenna device has the same equivalent circuit as the right half.

[0028] A resonance frequency of the antenna device having the above-described configuration will be described.

[0029] The resonance frequency of the antenna device is determined by a combined capacitance Ct ($=C_{T1}\times C_{T2}/(C_{T1}+C_{T2})$) of the varactor diodes 15a and 16a, the inductance Lm of the pattern inductor 12a, and the capacitance Cr and inductance Lr of the bridge 13.

[0030] The combined capacitance Ct ($=C_{T1}\times C_{T2}/(C_{T1}+C_{T2})$) of the varactor diodes 15a and 16a is large in the region where the tuning voltage (bias voltage) applied to the varactor diodes 15a and 16a is low. Accordingly, the antenna device according to the embodiment resonates at a low frequency with the combined capacitance Ct, the inductance Lm of the pattern inductor 12a, and the capacitance Cr and inductance Lr of the bridge 13. In the region where the bias voltage applied to the varactor diodes 15a and 16a is high, the combined capacitance Ct ($=C_{T1}\times C_{T2}/(C_{T1}+C_{T2})$) of the varactor diodes 15a and 16a is small. Accordingly, the antenna device resonates at a high frequency with the combined capacitance Ct, the inductance Lm of the pattern inductor 12a, and the capacitance Cr and inductance Lr of the bridge 13.

[0031] When the load resistor (bridge 13 and resistor 14) is not provided at the end portions of the radial conductors, the antenna device operates in a serial resonance mode. Accordingly, the inductance is fixed, and the resonance Q of the antenna becomes high when the combined capacitance Ct is decreased. Therefore, the band width of frequency characteristics based on the resonance frequency is narrowed.

[0032] In the embodiment, the bridge 13 and the resistor 14 are provided at both ends of the meander lines 11a and 11b. Accordingly, the impedance of the radial conductors formed of meander lines 11a and 11b decreases, and the resonance Q decreases as compared with the case where the end portions of the radial conductors are open. Thus, the band width (expansion of frequency characteristic from the middle of resonance frequency) at each operating frequency is widened, the resonance Q of the antenna particularly at the time of decreasing the combined capacitance Ct decreases, and it is possible to widen the band width of the operating frequency band in the high frequency band.

[0033] FIG. 3 is a diagram illustrating comparison of characteristics between the dipole antenna device according to the embodiment and the antenna device shown in FIG. 8. Parameters were set as follows: the tuning voltage Vt for reception in high frequency band is set to Vt=3 V (application voltage of varactor diode), the resonance frequency of the antenna device is set to 770 MHz, the load resistor R provided at the end portions of the radial conductors is set to R=Open, R=20 kΩ, and

R=10 kΩ. As a result of simulation, characteristics W1, W2, and W3 were obtained.

[0034] When the load resistor provided at the end portions of the radial conductors was R=Open (load resistor was not provided), that is, as a result of simulation using the antenna device shown in FIG. 8, the characteristic W1 having a peak P1 was obtained. As can be seen in the characteristic W1, the band width of the operating frequency is narrow as an antenna, and stability of reception is poor.

[0035] When the load resistor R=20 kΩ was provided, the characteristic W2 having a peak P2 was obtained. As can be seen in the characteristic W2, the band width is wide and it is possible to perform a stable reception operation, as compared with the characteristic W1 provided with no resistor at the end portions of the radial conductors. When the load resistor R=10 kΩ was provided, the characteristic W3 having a peak P3 was obtained. As can be seen in the characteristic W3, the band width is wide and it is possible to perform a stable reception operation, as compared with the characteristic W1 provided with no resistor at the end portions of the radial conductors and the characteristic W2 provided with the load resistor R=20 kΩ.

[0036] Parameters are set as follows: the tuning voltage Vt for reception in low frequency band is set to Vt=0 V (application voltage of varactor diode), the resonance frequency of the antenna device is set to 470 MHz, the load resistor R provided at the end portions of the radial conductors is set to R=Open, R=20 kΩ, and R=10 kΩ. As a result of simulation, characteristics W4, W5, and W6 were obtained.

[0037] When tuning to 470 MHz, the characteristic W4 having a peak P4 was obtained in the case of the load resistor R=Open provided at the end portions of the radial conductors. In the case of the load resistor R=20 kΩ, the characteristic W5 having a peak P5 was obtained. In the case of the load resistor R=10 kΩ, the characteristic W6 having a peak P6 was obtained. As can be seen in the characteristic W6, the band width is wide and it is possible to perform a more stable reception operation, as compared with the characteristic W4 provided with no resistor at the end portions of the radial conductors and the characteristic W5 provided with the load resistor R=20 kΩ.

[0038] According to the embodiment as described above, since the load resistor (resistance component of bridge 13 and resistor 14) is provided at both end portions of the meander lines 11a and 11b, it is possible to decrease the impedance of the end portions of the radial conductors and to decrease the resonance Q of the antenna. Particularly, it is possible to decrease the resonance Q of the antenna at the time of applying the tuning voltage Vt for reception in the high frequency band to the varactor diodes 15 and 16. Accordingly, it is possible to perform a stable reception operation by widening the operating frequency band.

(Second Embodiment)

[0039] Next, an antenna device according to a second embodiment of the invention will be described.

[0040] FIG. 4 is a diagram illustrating a configuration of an antenna device according to the second embodiment, and FIG. 5 is an equivalent circuit diagram illustrating one side of the antenna device according to the second embodiment. The same reference numerals and signs are given to the same portions as the antenna device according to the first embodiment shown in FIG. 1, and the overlapping description is omitted.

[0041] In the antenna device according to the embodiment, the load resistor provided at the end portions of the radial conductors is formed of (R+C) as well as R formed of the resistor 14, to suppress decreases of low frequency band gain of the tuning band. That is, both ends of the meander lines 11a and 11b are connected by the bridge 13, and the resistor 14 and a capacitor 18 are connected in series in the middle of the bridge 13. The capacitor 18 has high impedance at a frequency lower than the first frequency band and thus serves as a coupled capacitor which does not allow signals to pass. As the capacitor 18, a capacitance is selected, which has high impedance with respect to the first frequency band or lower in which it is necessary to provide a resistor at the end portions of the radial conductors to lower the resonance Q of the antenna.

[0042] In the antenna device having the above-described configuration, the capacitor 18 has high impedance and does not allow signals to pass in the low operating frequency band in which it is not necessary to provide the resistor at the end portions of the radial conductors. Accordingly, both end portions of the meander lines 11a and 11b are open or are in a state similar to the open state, and thus loss of gain is suppressed. As shown in the characteristic W4 in Fig. 3, even when the resistor is not provided at the end portions of the radial conductors in the low operating frequency band, it is possible to realize an operating frequency band capable of securing a stable reception operation.

[0043] On the other hand, the capacitor 18 becomes low impedance and thus both end portions of the meander lines 11a and 11b are connected to each other in the operating frequency or higher in which it is necessary to provide the resistor at the end portions of the radial conductors. As a result, the resistor 14 is provided at the end portions of the radial conductors that are both end portions of the meander lines 11a and 11b. Accordingly, it is possible to decrease the resonance Q of the antenna, and it is possible to widen the operating frequency band in the high frequency band.

[0044] According to the embodiment as described above, both end portion of the meander lines 11a and 11b are connected by the bridge 13, and the resistor 14 and the capacitor 18 are connected in series in the middle of the bridge 13. Accordingly, it is possible to widen the operating frequency band in the high frequency band,

and it is possible to suppress decrease of gain in the low frequency band.

(Third Embodiment)

[0045] In the above description, the dipole antenna device has been described by way of example, but the invention is applicable to a monopole antenna device.

[0046] FIG. 6 is a diagram illustrating a configuration of an antenna device according to a third embodiment of the invention. The same reference numerals and signs are given to the same portions as the antenna device according to the first embodiment shown in FIG. 1 and FIG. 2, and the overlapping description is omitted.

[0047] The antenna device according to the embodiment is a monopole compact tunable antenna device, in which a resistor and a capacitor are connected in series between the end portion of the radial conductor and the ground pattern GND. That is, one end portion of the capacitor 18 is connected to the end portion of the meander line 11, and the ground pattern GND is connected to the other end of the capacitor 18 through the resistor 14. Cathodes of the varactor diodes 15 and 16 as variable capacitance elements are connected to each other, and the tuning voltage Vt is applied to the both cathodes through the inductor 19a. End portions of the power supply portion 10 and the resistor 14 close to the ground are connected to each other through the ground pattern GND. With such a configuration, a closed loop is formed by the ground pattern GND, the resistor 14, and the capacitor 18, between the end portion of the meander line 11 and the power supply portion 10. The cathodes of the varactor diodes 15 and 16 are connected to the ground pattern GND through the inductor 19b.

[0048] In the antenna device having the above-described configuration, the capacitor 18 has high impedance and does not allow signals to pass in the low operating frequency band in which it is not necessary to provide the resistor at the end portion of the radial conductor. Accordingly, the end portion of the meander line 11 is open, and loss of gain is suppressed.

[0049] On the other hand, in the operating frequency or higher in which it is necessary to provide the resistor at the end portion of the radial conductor, the capacitor 18 has low impedance, the end portion of the meander line 11 and the ground pattern GND are connected to each other, and the resistor 14 is provided at the end portion of the radial conductor that is the end portion of the meander line 11. Accordingly, it is possible to decrease the resonance Q of the antenna, and thus it is possible to widen the operating frequency band in the high frequency band.

[0050] The antenna device according to the third embodiment is provided with the capacitor 18 and has the frequency characteristic. However, in the case where gain loss is permissible in the low frequency band, the capacitor 18 may not be provided.

[0051] The tunable antenna provided with the variable capacitance element between the power supply portion and the radial conductor has been described above. However, the invention is not limited to the tunable antenna. For example, the invention is applicable to a dipole or monopole antenna device in which one end of the radial conductor is open, even when the antenna device is not the tunable antenna.

[0052] It should be understood by those skilled in the art that various modifications, combinations, subcombinations and alterations may occur depending on design requirements and other factors insofar as they are within the scope of the appended claims of the equivalents thereof.

Claims

1. An antenna device comprising:

   a power supply portion;
   a radial conductor, one end of which is connected to the power supply portion and the other end is open; and
   a resistor connected to the open end of the radial conductor,
   wherein a closed loop for decreasing impedance of the radial conductor is formed by the power supply portion, the radial conductor, and the resistor.

2. The antenna device according to Claim 1, wherein the radial conductor is formed by first and second radical conductors disposed with the power supply portion therebetween to form a dipole antenna, and the resistor is connected between the open ends of the first and second radial conductors.

3. The antenna device according to Claim 2, wherein the open ends of the first and second radial conductors are connected to each other by a conductive bridge, and the bridge is provided with the resistor.

4. The antenna device according to Claim 1, wherein the power supply portion is connected to the one end of the radial conductor to form a monopole antenna, the resistor is connected between the open end of the radial conductor and a ground pattern, and the power supply portion and the end portion on the ground side of the resistor are connected through the ground pattern.

5. The antenna device according to any one of Claims 1 to 4, wherein a variable capacitance element is provided between the power supply portion and the radial conductor, and the antenna device is a tunable antenna capable of being tuned to a desired frequency by applying bias voltage to the variable capacitance element.

6. The antenna device according to any one of Claims 1 to 5, wherein a capacitor is connected to the resistor in series.

7. The antenna device according to any one of Claims 1 to 6, wherein the radial conductor is formed in a meander shape.

FIG. 1

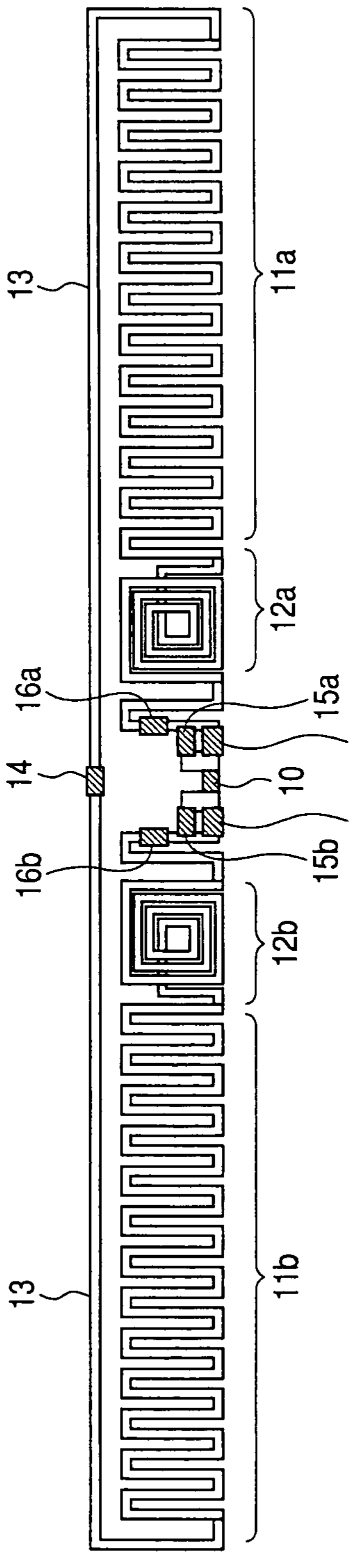


FIG. 2

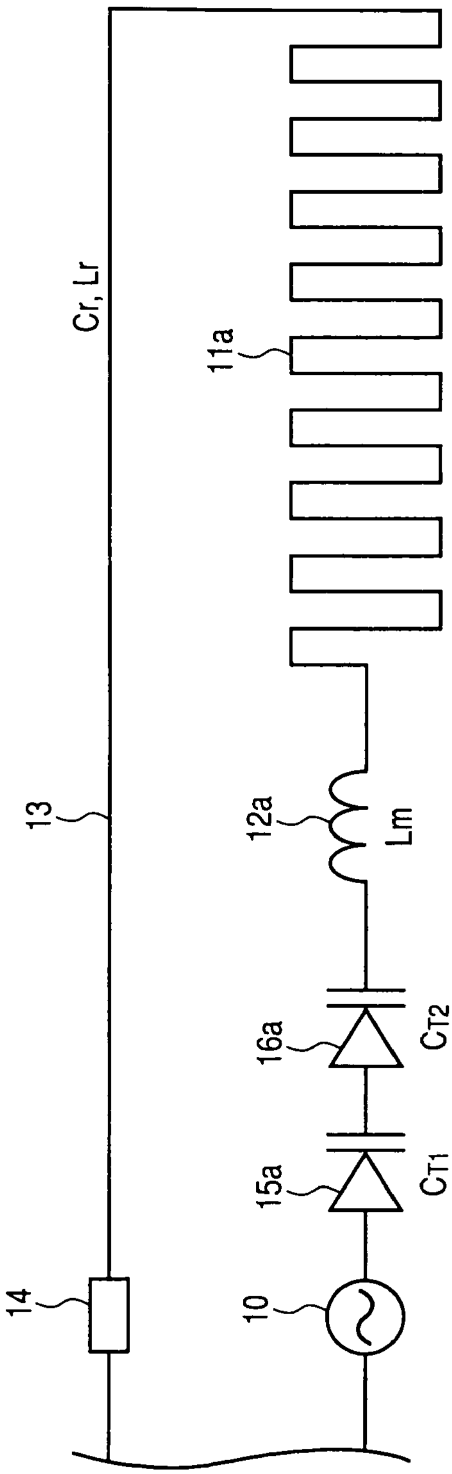


FIG. 3

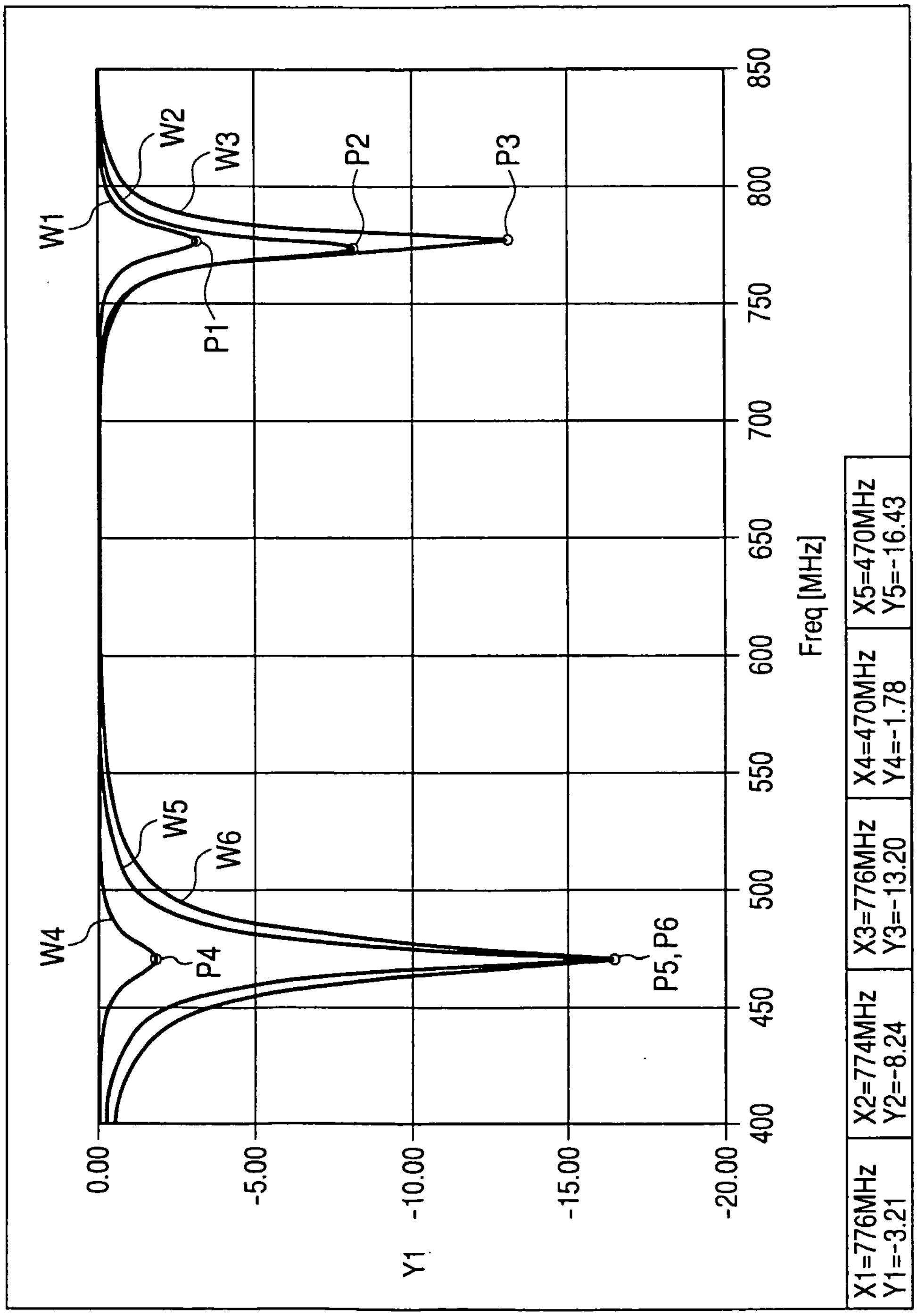

W1
W2
W3
P1
P2
P3
W4
W5
W6
P4
P5, P6
0.00
-5.00
-10.00
-15.00
-20.00
Y1
400
450
500
550
600
650
700
750
800
850
Freq [MHz]
X1=776MHz
Y1=-3.21
X2=774MHz
Y2=-8.24
X3=776MHz
Y3=-13.20
X4=470MHz
Y4=-1.78
X5=470MHz
Y5=-16.43

FIG. 4

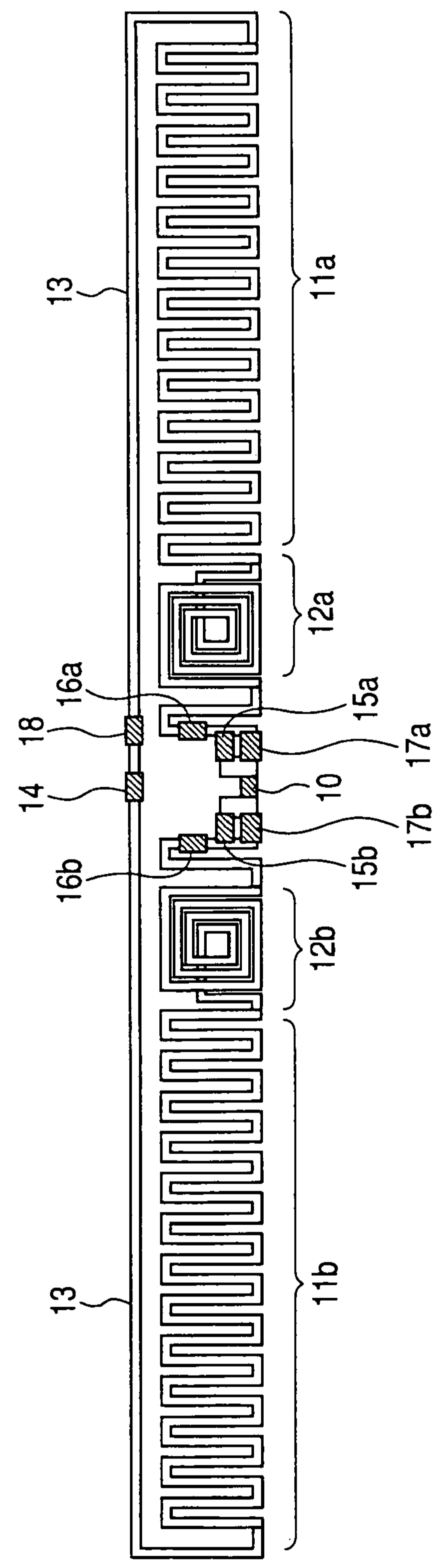


FIG. 5

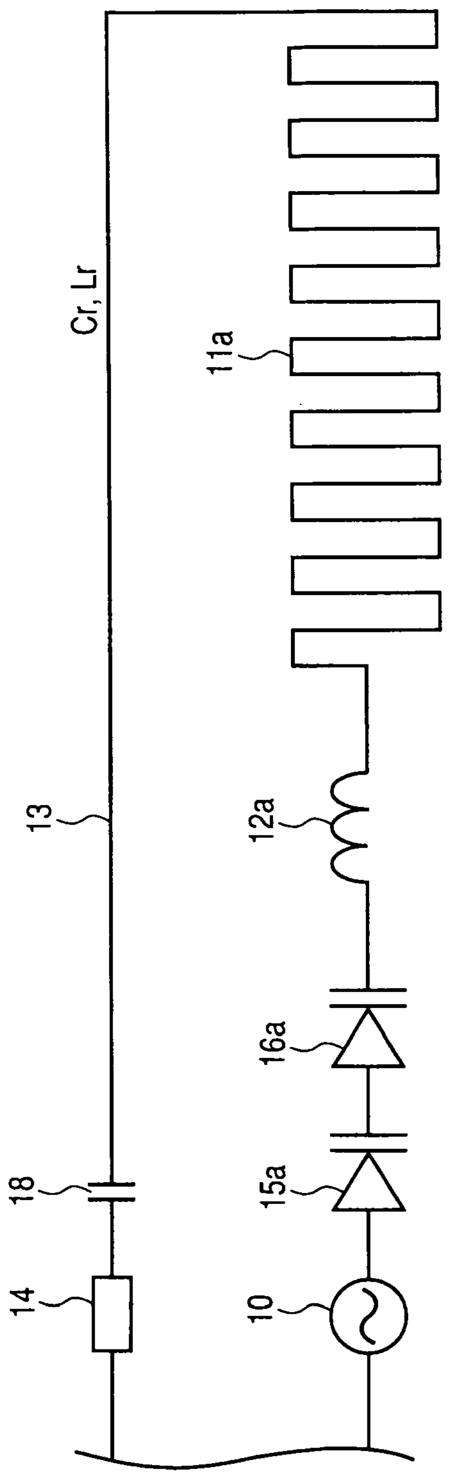


FIG. 6

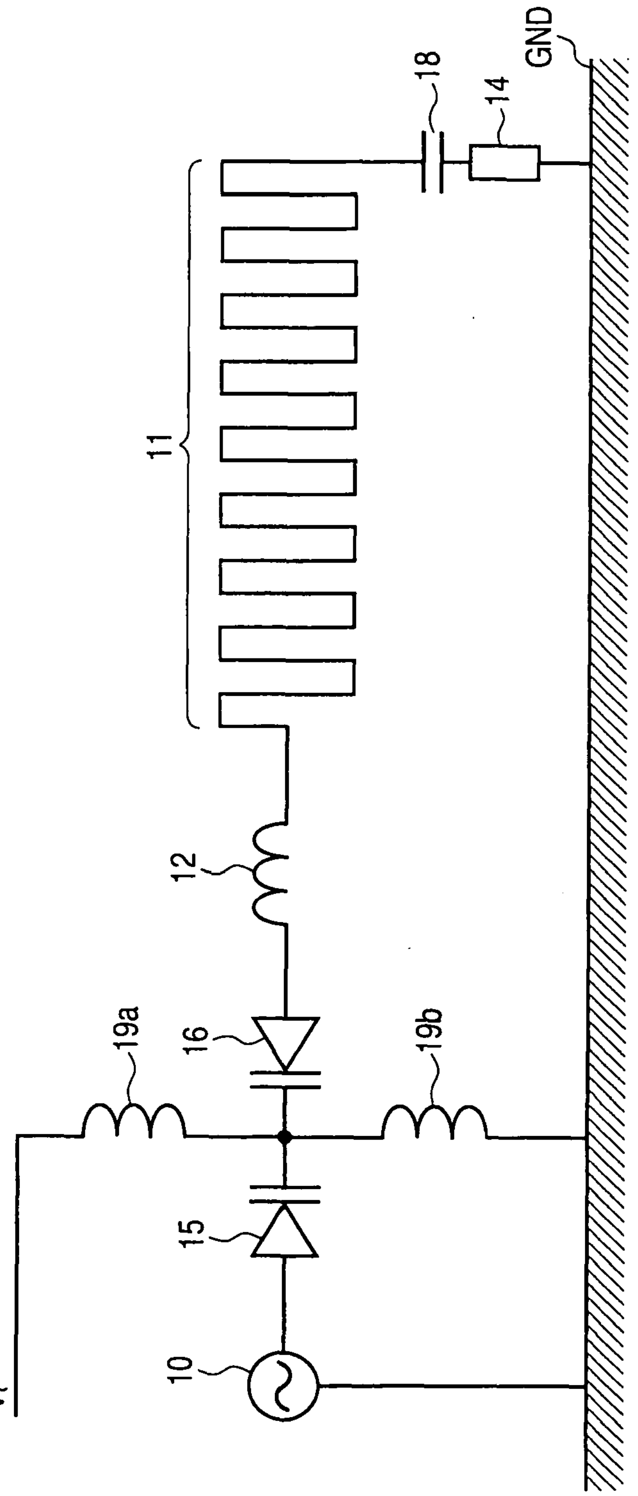
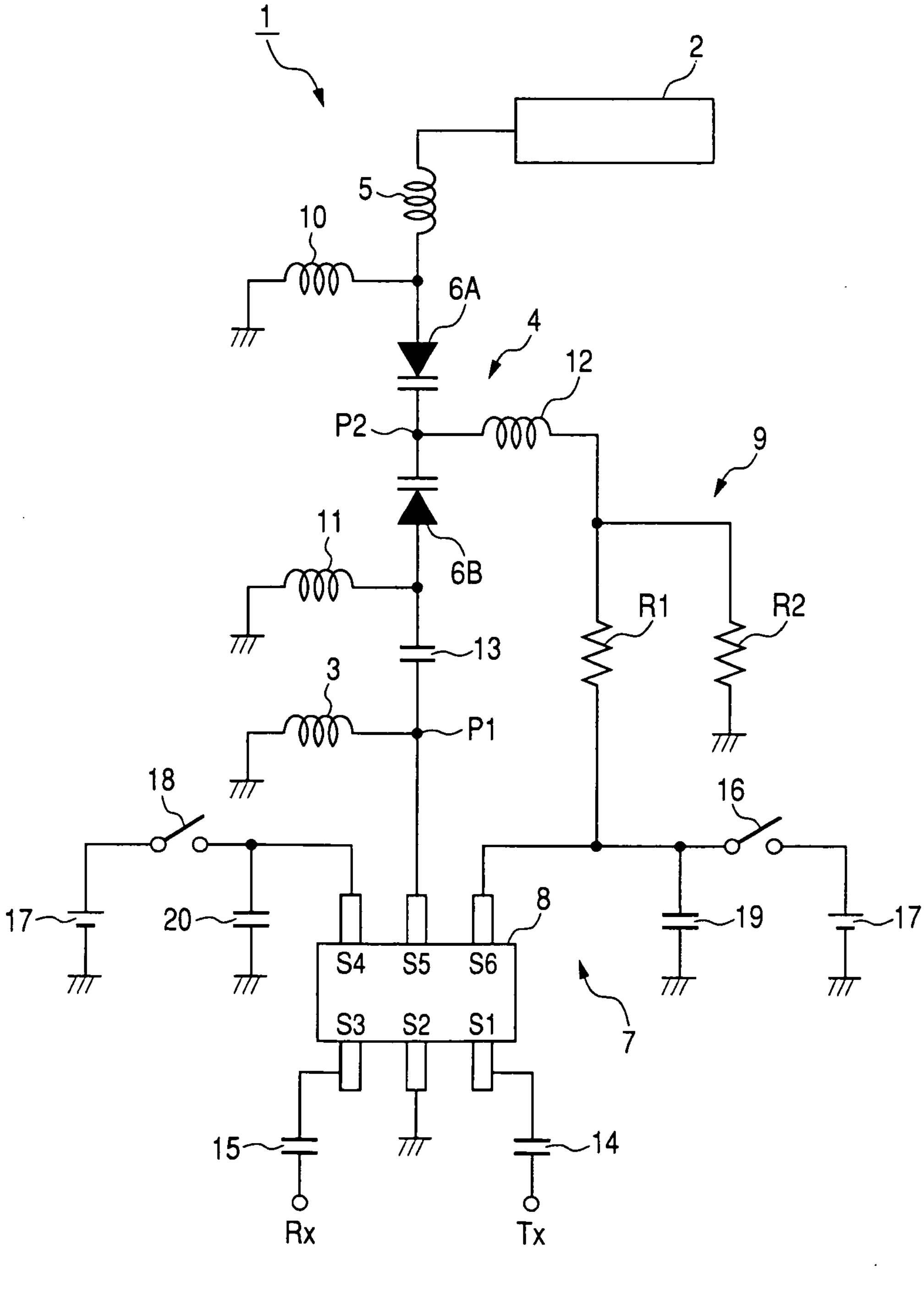


FIG. 7


1
2
5
10
6A
4
12
P2
9
11
6B
R1
R2
13
3
P1
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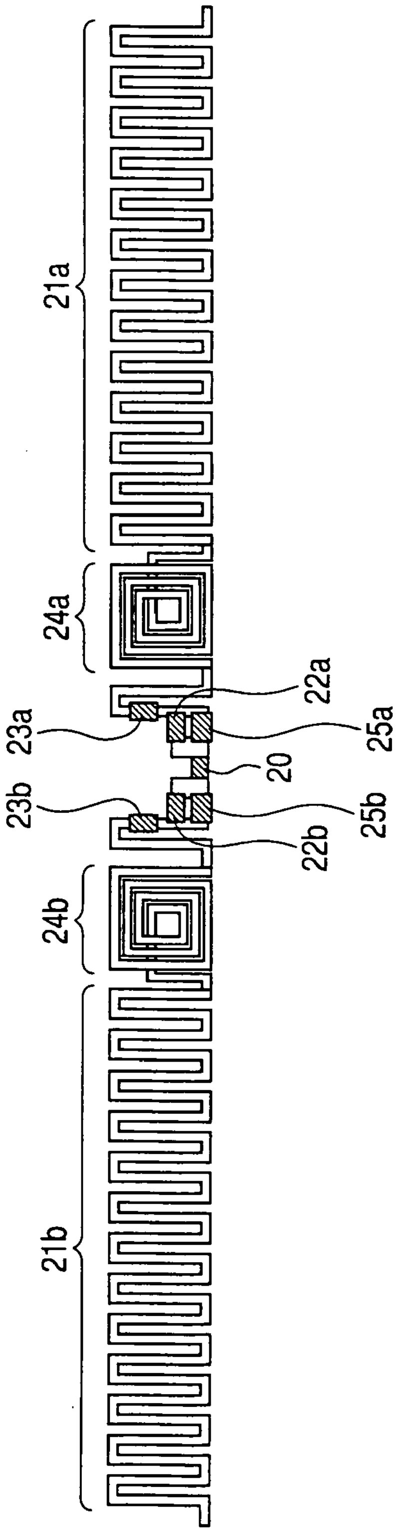
16
17
20
S4
S5
S6
8
19
17
S3
S2
S1
7
15
14
Rx
Tx

FIG. 8



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EUROPEAN SEARCH REPORT

Application Number
EP 09 00 1635

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	GB 1 507 674 A (C S ANTENNAS LTD) 19 April 1978 (1978-04-19) * page 2, lines 54-68; figure 4 * -----	1,3,6	INV. H01Q7/00 H01Q9/04
A	EP 1 885 022 A (MATSUSHITA ELECTRIC IND CO LTD [JP] PANASONIC CORP [JP]) 6 February 2008 (2008-02-06) * abstract; figure 1 * * column 7, paragraph 35 * * column 10, paragraph 46 * -----	4	
A	WO 2007/049193 A (KONINKL PHILIPS ELECTRONICS NV [NL]; TSILIOUKAS EFTHIMIOS [GR]; BOEKES) 3 May 2007 (2007-05-03) * abstract; figures 1,2 * * page 4, lines 1-4 * * page 5, line 5 - page 7, line 20 * -----	4-7	

TECHNICAL FIELDS SEARCHED (IPC)
H01Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 June 2009	Cordeiro, J

4

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
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