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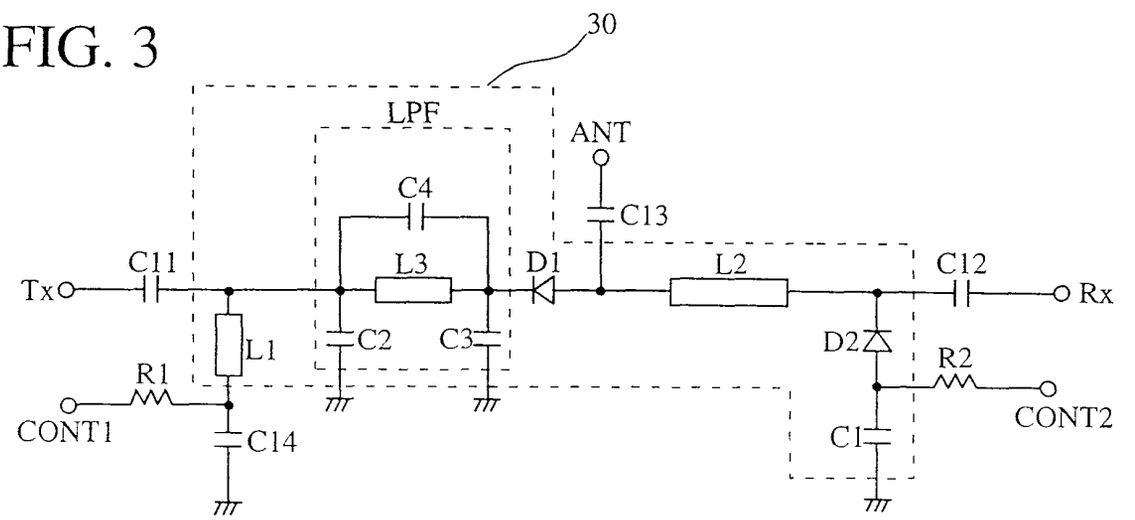
(54) Composite switch circuit and composite switch device

(57) A composite switch circuit (30) for alternately and electrically connecting a first circuit (Tx) to a third circuit (ANT) or a second circuit (Rx) to said third circuit (ANT). The composite switch circuit (30) is incorporated with a low pass filter circuit (LPF) in the switch circuit portion of the composite switch circuit (30) so as to create a highly symmetrical circuit configuration. The composite switch circuit (30) is disposed on a plurality of dielectric substrates (22-28) of a integral multi-layer body (2) to provide a miniaturised composite switch device. Since the composite switch device including the composite switch circuit (30) with a symmetrical circuit configuration shows a low insertion loss and a high performance in a broad frequency range, the composite switch device is advantageously used to form a portion of a radio transceiver such as a cellular radiotelephone.

FIG. 3



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a switch circuit, and particularly to a composite switch circuit comprising a diode switch circuit incorporated with a low pass filter circuit for use as a high frequency switch circuit of a digital cellular radiotelephone. etc. to alternately switch transmission paths for transmitting or recciving communication signals. The present invention relates also to a composite switch device of an integral multilaycr body including the composite switch circuit.

[0002] A switch circuit for a digital cellular radiotelephone, etc. is utilized to alternately connect a receiving circuit to an antenna or a transmitting circuit to the antenna. In a radiotelephone employing a reception diversity system, the switch circuit also alternately connects a receiving circuit to a first antenna or the receiving circuit to a second antenna. Likely, in a base station for a radio communication system employing a transmission diversity system. the switch circuit is also utilized to alternately connect a transmitting circuit to a first antenna or the transmitting circuit to a second antenna.

[0003] In a radiotelephone having an external port for connecting an automotive booster, etc., the switch circuit is also used for switching a path to an internal circuit and a path to the external port. Further, the switch circuit is used for switching a plurality of channels of base stations for the radio communication system.

[0004] Fig. 11 is a schematic circuit diagram showing a conventional switch circuit disclosed in Japanese Patent Laid-Open No. 6-197040. In Fig. 11, the switch circuit alternately connects a transmitting circuit Tx to an antenna ANT or a receiving circuit Rx to the antenna ANT. The transmitting circuit Tx is connected to an anode of a first diode D101 via a first capacitor C101. A cathode of the first diode D101 is connected to the antenna ANT via a third capacitor C103. The antenna ANT is also connected to a receiving circuit Rx via series-connected third capacitor C103, second transmission line SL2 and fourth capacitor C104. An anode of the first diode D101 is grounded via series-connected first transmission line SL1 and second capacitor C102. Further, a control circuit T1 is connected to a node formed between the first transmission line SLI and the second capacitor C102 via a resistance R101. An anode of a second diode D102 is connected to a node formed between the second transmission line SL2 and the fourth capacitor C104, and a cathode thereof is grounded. The transmission lines and some of the capacitors are disposed on a plurality of substrates of a dielectric laminate body, and the diodes, resistance and the other of the capacitors are mounted on a top surface of the laminate body.

[0005] When a filter circuit is used with the switch circuit, the switch circuit and the filter circuit are separately formed and then connected together. Therefore, a large mounting area is needed, and an additional circuit for impedance-matching is required.

[0006] To solve the above problem, Japanese Patent Laid-Open No. 8-97743 discloses a composite device including a switch circuit and a filter circuit. An equivalent circuit of the composite device is shown in Fig. 12. In Fig. 12, a filter circuit portion is represented by a block shown in broken line. The filter circuit is positioned to interconnect a transmitting circuit Tx and the switch circuit. An equivalent circuit when the transmitting circuit Tx is electrically connected to the antenna ANT is shown in Fig. 13. In the equivalent circuit, the diodes D201 and D202 are not shown because they are on position by DC current and in low impedance state to form short circuits.

[0007] As seen from Fig. 13, a conventional circuit formed by simply connecting the filter circuit to the switch circuit lacks symmetry in the circuit configuration to exhibit a sufficient frequency characteristics only in a narrow frequency band. A narrow-band switch circuit is of less performance in view of the full utilization of the frequency band allocated for a communication system, and is poor in productivity due to the variability of products.

OBJECT AND SUMMARY OF THE INVENTION

[0008] Accordingly, an object of the present invention is to provide a broad band, composite switch circuit with a high symmetry in the circuit configuration and a miniaturized composite switch device of an integral multilayer structure including the composite switch circuit.

[0009] As a result of the intense research in view of the above objects, the inventors have found that the symmetry in the circuit configuration can be increased by disposing a low pass filter circuit between a diode and a transmission line in a switch circuit in stead of simply connecting the low pass filter circuit to the switch circuit, thereby decreasing the level of insertion loss and ensuring a high performance of the switch circuit in a broader frequency band as compared with conventionally known switch circuits.

[0010] Thus, in accordance with a first embodiment of the present invention, a composite switch circuit for alternately, and electrically connecting a first circuit to a third circuit or a second circuit to the third circuit, comprises (1) a first path interconnecting the first circuit and the third circuit, the first path including a first diode and a first transmission line, a first side portion of the first diode being connected to the third circuit, and a first side portion of the first transmission line being connected to a node formed between the first circuit and a second side portion of the first diode in a shunt configuration; (2) a second path interconnecting the second circuit and the third circuit, the second path including a second transmission line and a second diode, a first side portion of the second transmission line being connected to the third circuit, and a first side portion of the second diode being connected to a node formed between a second

side portion of the second transmission line and the second circuit in a shunt configuration; and (3) a low pass filter circuit disposed in the first path so as to interconnect the second side portion of the first diode and the first side portion of the shunt-connected first transmission line.

[0011] In the above embodiment, a second side portion of the first transmission line is grounded via a capacitor, and a first control circuit is connected in a shunt configuration to a node formed between the first transmission line and the capacitor via a resistance. Also, a second side portion of the second diode is grounded via another capacitor, and a second control circuit is connected in a shunt configuration to a node formed between the second diode and the capacitor via a resistance. The first and second control circuits control whether the first circuit or the second circuit is electrically connected to the third circuit by switching ON state (low impedance) and Off state (high impedance) of the first and second diodes.

[0012] The first, second and third circuits may be a transmitting circuit, a receiving circuit and an antenna. respectively. Thus, the composite switch circuit of the present invention may be a switch circuit incorporated with a low pass filter circuit, operable to alternately connect the transmitting circuit to the antenna or the receiving circuit to the antenna.

[0013] In a preferred embodiment of the composite switch circuit of the present invention, the first, second and third circuits may be a transmitting circuit, a receiving circuit and an antenna, respectively, and a cathode portion of the first diode is connected to the transmitting circuit and an anode portion of the first diode is connected to the antenna. Also, a cathode portion of the second diode is connected to the receiving circuit and an anode portion of the second diode is grounded. Thus, the low pass filter circuit is connected between the cathode portion of the first diode and the shunt-connected first transmission line.

[0014] In another preferred embodiment of the composite switch circuit of the present invention, the first, second and third circuits may be a transmitting circuit, a receiving circuit and an antenna, respectively, and the anode portion of the first diode is connected to the transmitting circuit and the cathode portion of the first diode is connected to the antenna. Also, the anode portion of the second diode is connected to the receiving circuit and the cathode portion of the second diode is grounded. Thus, the low pass filter circuit is connected between the anode portion of the first diode and the shunt-connected first transmission line.

[0015] In accordance with a second embodiment of the present invention, a composite switch device comprising a composite switch circuit disposed on a plurality of dielectric substrates of an integral multi-layer body, the composite switch circuit being operable to alternately and electrically connect a first circuit to a third circuit or a second circuit to the third circuit and comprising (1) a first path interconnecting the first circuit and the third circuit, the first path including a first diode and a first transmission line, a first side portion of the first diode being connected to the third circuit, and a first side portion of the first transmission line being connected to a node formed between the first circuit and a second side portion of the first diode in a shunt configuration; (2) a second path interconnecting the second circuit and said third circuit, the second path including a second transmission line and a second diode, a first side portion of the second transmission line being connected to the third circuit, and a first side portion of the second diode being connected to a node formed between a second side portion of the second transmission line and the second circuit in a shunt configuration; and (3) a low pass filter circuit disposed in the first path so as to interconnect the second side portion of the first diode and the first side portion of the shunt-connected first transmission line; and at least the first transmission line, second transmission line and a part of the low pass filter circuit being disposed on at least one inner dielectric substrate in the integral multi-layer body.

[0016] In the above embodiment, the first diode and the second diode may be disposed on the top surface of the integral multi-layer body.

[0017] By disposing at least the first transmission line, the second transmission line and a part of the low pass filter circuit on at least one inner substrates in the integral multi-layer body and/or disposing the diodes on the top surface of the integral multi-layer body, a composite switch device of a single body can be obtained. Also, elements such as a capacitor, a resistance, an inductor, etc. may be disposed on the top surface of the integral multi-layer body. The elements to be disposed on the top surface of the integral multi-layer body may be suitably selected depending on the elements disposed on the inner substrates of the integral multi-layer body.

[0018] The composite switch device may include at least two ground electrodes disposed on the dielectric substrates. The first and second transmission lines disposed on inner dielectric substrates in the integral multi-layer body may be positioned between two of the ground electrodes. Each of the capacitors for the low pass filter circuit may be formed by the upper ground electrode of two ground electrodes sandwiching the first and second transmission lines and an electrode disposed upper side and opposite to the upper ground electrode. By incorporating a ground electrode between the transmission lines and the low pass filter circuit in the above manner, undesirable interference between the transmission lines and the low pass filter circuit can be suppressed.

[0019] In the composite switch device of the present invention, the electrodes forming plates of the capacitors of the low pass filter circuit may be respectively disposed on dielectric substrates positioned upper side the first and second transmission lines with respect to the mounting surface of the composite switch device.

[0020] The first and second transmission lines are

preferred to be formed by electrode patterns of a spiral form, because the spiral electrode patterns make the length of the path of the transmission lines shorter.

[0021] In a preferred embodiment of the composite switch device of the present invention, the first, second and third circuits may be a transmitting circuit, a receiving circuit and an antenna, respectively. and a cathode portion of the first diode is connected to the transmitting circuit and an anode portion of the first diode is connected to the antenna. Also, a cathode portion of the second diode is connected to the receiving circuit and an anode portion of the second diode is grounded. Thus, the low pass filter circuit is connected between the cathode portion of the first diode and the shunt-connected first transmission line.

[0022] In another preferred embodiment of the composite switch device of the present invention, the first, second and third circuits may be a transmitting circuit, a receipting circuit and an antenna, respectively, and the anode portion of the first diode is connected to the transmitting circuit and the cathode portion of the first diode is connected to the antenna. Also, the anode portion of the second diode is connected to the receiving circuit and the cathode portion of the second diode is grounded. Thus, the low pass filter circuit is connected between the anode portion of the first diode and the shunt-connected first transmission line.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023]

Fig. 1 is a perspective view showing a composite switch device of the present invention;

Fig. 2 is a perspective view showing respective substrates constructing the integral multi-layer body of the composite switch device shown in Fig. 1;

Fig. 3 is a schematic circuit diagram showing an equivalent circuit of a radio transceiver circuit including a composite switch circuit of the present invention;

Fig. 4 is a schematic circuit diagram showing an equivalent circuit of Fig. 3, in which the transmitting circuit Tx is electrically connected to the antenna ANT;

Fig. 5 is a schematic circuit diagram showing an equivalent circuit of a radio transceiver circuit including another composite switch circuit of the present invention;

Fig. 6A is a graph showing the insertion loss at a frequency up to 5.5 GHz measured on the composite switch device of the present invention;

Fig. 6B is a graph showing the enlarged passband of Fig. 6A;

Fig. 7 is a schematic circuit diagram showing an equivalent circuit of the low pass filter portion of the composite switch circuit of the present invention;

Fig. 8 is a perspective view showing respective substrates constructing an integral multi-layer body disposed by another composite switch circuit of the present invention;

Fig. 9 is a schematic circuit diagram showing an equivalent circuit of a transceiver circuit including the composite switch circuit disposed on the integral multi-layer body of Fig. 8;

Fig.10 is a schematic circuit diagram showing a partial equivalent circuit of still another composite switch circuit of the present invention;

Fig. 11 is a schematic circuit diagram showing an equivalent circuit of a conventional switch circuit;

Fig. 12 is a schematic circuit diagram showing an equivalent circuit of another conventional switch circuit; and

Fig. 13 is a schematic circuit diagram showing an equivalent circuit of the conventional switch circuit of Fig. 12, in which the transmitting circuit Tx is electrically connected to the antenna ANT.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] As summarized above, the composite switch circuit of the present invention is a switch circuit incorporated with a low pass filter circuit, and is operable to alternately and electrically connecting a first circuit to a third circuit or a second circuit to the third circuit. In a preferred embodiment, the composite switch circuit may be an antenna switch circuit in which the first circuit is a transmitting circuit, the second circuit is a receiving circuit, and the third circuit is an antenna. The present invention will be described more in detail with respect to such an antenna switch circuit. However, it should be considered to illustrate one of various preferred embodiments of the present invention.

[0025] In the present invention, a circuit for a low pass filter circuit is incorporated into a switch circuit to form a single composite switch circuit. The composite switch circuit may be disposed on a plurality of dielectric substrates to form a miniaturized composite switch device of an integral multi-layer body.

[0026] An equivalent circuit of a radio transceiver circuit including a composite switch circuit of the present invention is shown in Fig. 3. In the equivalent circuit, the first circuit is a transmitting circuit Tx, the second circuit is a receiving circuit Rx, and the third circuit is an antenna ANT. A composite switch circuit 30 within a block indicated by broken line includes a first path interconnecting the transmitting circuit Tx and the antenna ANT and a second path interconnecting the receiving circuit Rx and the antenna ANT. The first path includes a first diode D1 and a first transmission line L1, a first side portion of the first diode D1 being connected to the antenna ANT and a first side portion of the first transmission line L1 being connected to a node between a second side portion of the first diode D1 and the transmitting circuit Tx in a shunt configuration. The second path includes a

second transmission line L2 and a second diode D2, a first side portion of the second transmission line L2 being connected to the antenna ANT and a first side portion of the second diode D2 being connected to a node between a second side portion of the second transmission line L2 and the receiving circuit Rx in a shunt configuration.

[0027] The low pass filter circuit LPF within a block indicated by broken line is incorporated into the switch circuit so as to interconnect the second side portion of the first diode D1 and the first side portion of the shunt-connected first transmission line L1, thereby to form the composite switch circuit of the present invention. As shown in Fig. 3, the low pass filter circuit LPF usually comprises a transmission line L3, a capacitor C4 in parallel to the transmission line L3, and capacitors C2 and C3 each forming a shunt path to ground.

[0028] Further, as seen from Fig. 3, a second side portion of the transmission line L1 is grounded via a capacitor C14, and a first control circuit CONT1 is shunt-connected between the first transmission line L1 and the capacitor C14 via a resistance R1. The CONT1 may be omitted, and if omitted, the first transmission line L1 may be directly grounded. Further, a second side portion of the second diode D2 is grounded via a capacitor C1, and a second control circuit CONT2 is shunt-connected between the second diode D2 and the capacitor C1 via a resistance R2. The control circuits control whether the transmitting circuit Tx (first circuit) or the receiving circuit Rx (second circuit) is electrically connected to the antenna ANT (third circuit) by biasing the diodes D1 and D2. To each input/output terminal of the transmitting circuit Tx, the receiving circuit Rx and the antenna ANT, connected is a DC cutting capacitor C11, C12 or C13 for passing only high frequency signals therethrough.

[0029] In the present invention, the low pass filter circuit is not simply connected to a switch circuit, but is incorporated into the switch circuit, more specifically, is incorporated between the second side portion of the first diode D1 and the first side portion of the shunt-connected first transmission line L1. An equivalent circuit of Fig. 3 when the transmitting circuit Tx is electrically connected to the antenna ANT is shown in Fig. 4. In Fig. 4, the diodes D1 and D2 are not shown because they are in a highly conducting, low impedance state to form short circuits.

[0030] As seen from Fig. 4, the composite switch circuit of the present invention is highly symmetric in the circuit configuration. Namely, the transmitting circuit Tx, the capacitor C11, the transmission line L1 and the capacitor C14 are positioned symmetrically with the antenna ANT, the capacitor C13, the transmission line L2 and the capacitor C1(C12), respectively, with respect to the central low pass filter circuit. With such a symmetry in the circuit configuration, the composite switch circuit of the present invention exhibits a lower level of insertion loss and sufficient characteristics in a broader frequency band as compared with conventional switch circuits.

[0031] An equivalent circuit of another composite switch circuit 50 of the present invention is shown in Fig. 5. The equivalent circuit of Fig. 5 is similar to that of Fig. 3, but in which the first and second diodes D1 and D2 are reversely connected with respect to anode and cathode. When the transmitting circuit Tx is electrically connected to the antenna ANT, the circuit of Fig. 5 has the same equivalent circuit as shown in Fig. 4. Namely, the composite switch circuit of Fig. 5 has also a high symmetry in the circuit configuration, and exhibits a lower level of insertion loss and sufficient characteristics in a broader frequency band as compared with conventional switch circuits.

[0032] The equivalent circuit of Fig. 3 has been experimentally confirmed to have a lower level of insertion loss and a good isolation as compared with the equivalent circuit of Fig. 5.

[0033] Fig. 1 is a perspective view showing a composite switch device of the present invention. Substrates constructing the integral multi-layer body of the composite switch device of Fig. I are perspectively shown in Fig. 2, and an equivalent circuit of a composite switch circuit disposed on a plurality of dielectric substrates of the composite switch device of Figs. 1 and 2 is shown in Fig. 3.

[0034] As seen from Fig. 1, the composite switch device comprises a semiconductor element 1 containing two diodes and an integral multi-layer body 2 of a plurality of dielectric substrates. In Figs. 1 and 2, a portion indicating the electrodes are shown by hatch makings.

[0035] In Fig. 3, the composite switch circuit of the present invention comprises the elements contained within the block 30 indicated by broken line, and capacitors C11, C12, C13, C14 and the resistances R1 and R2 outside the block 30 are external elements which may be formed on a circuit board on which the composite switch device is mounted, or may be disposed on the dielectric substrates or the top surface of the integral multi-layer body.

[0036] As seen from Fig. 2, the composite switch device of the embodiment comprises a bottom dielectric substrate 21, inner substrates 22-28 and a top dielectric substrate 29.

[0037] On the top surface of the bottom dielectric substrate 21, a first ground electrode 31 is formed, from which lead electrodes extend to be connected to external electrodes T2, T7 and T8 on the side surface of the integral multi-layer body 2.

[0038] On the top surface of the dielectric substrate 22 laminated on the bottom dielectric substrate 21, a capacitor electrode 41 opposing the first ground electrode 31 is formed so as to form the capacitor C1. A lead electrode extending from the capacitor electrode 41 is connected to an external electrode T4. Although the capacitor C1 is formed inside the integral multi-layer body in this embodiment, it may be externally formed, for example, on the top surface of the top dielctric surbstrate 29 or on the circuit board on which the composite switch

device is mounted.

[0039] On the dielectric substrate 22, dielectric substrates 23 and 24 having electrodes forming the transmission lines are laminated. A spiral line electrode 11 on the dielectric substrate 23 is connected to a spiral line electrode 12 on the dielectric substrate 24 via a through-hole electrode 51 to form the transmission line L1. Two lead electrodes extend from the spiral line electrodes 11 and 12 to be respectively connected to external electrodes T3 and T6. A spiral line electrode 13 on the dielectric substrate 23 is connected to a spiral line electrode 14 on the dielectric substrate 24 via a through-hole electrode 52 to form the transmission line L2. Two lead electrodes extend from the spiral line electrodes 13 and 14 to be respectively connected to external electrodes T5 and T1.

[0040] On the top surface of a dielectric substrate 25 laminated on the dielectric substrate 24, a second ground electrode 32 is formed. Three lead electrodes extend from the second ground electrode 32 to be respectively connected to the external electrodes T2, T7 and T8.

[0041] On the dielectric substrate 25, a dielectric substrate 26 is laminated. On the top surface the dielectric substrate 26, a capacitor electrode 42 opposing the second ground electrode 32 is formed to form the capacitor C2 of the low pass filter circuit. Also formed on the dielectric substrate 26 is a capacitor electrode 43 opposing the second ground electrode 32 to form the capacitor C3 of the low pass filter circuit. From the capacitor electrode 42, a lead electrode extends to be connected to the external electrode T3.

[0042] A capacitor electrode 44 opposing the capacitor electrode 42 of the dielectric substrate 26 is formed on the top surface of a dielectric substrate 27 to form the capacitor C4 of the low pass filter circuit. The capacitor electrode 44 is connected to the capacitor electrode 43 on the dielectric substrate 26 via a through-hole 53.

[0043] On the top surface of the dielectric substrate 28, a spiral line electrode 15 forming the transmission line L3 of the low pass filter circuit is formed. An end of the spiral line electrode is connected to the external electrode T3, and the opposite end is connected to the capacitor electrodes 44 and 43 via the through-holes 54 and 53.

[0044] On the top surface of the top dielectric substrate 29, pattern electrodes 16 and 17 are formed. The pattern electrode 16 is connected to the through-hole 54 on the dielectric substrate 28 via a through-hole 55. The pattern electrode 17 serves as a marker. On the top surface of the top dielectric substrate 29, pattern electrodes to be connected to the external electrodes T1, T4, T5 and T6 are further formed.

[0045] An composite switch device having the above construction was produced by using dielectric material having a dielectric constant of about 8. The dielectric material was made into a sheet form (dielectric substrates) by a doctor blade and respective pattern electrodes were formed on the dielectric sheets by screen-printing an electrically conductive material such as Ag. The dielectric substrates having thereon pattern electrodes printed were laminated, compressed and fired to an integral multi-layer body. After firing, the external electrodes T1 to T8 and the pattern electrodes were formed on the side surface and the top surface of the integral multi-layer body. Finally, the semiconductor element 1 containing the first and second diodes D1 and D2 was mounted on the top surface of the integral multi-layer body so that the first diode D1 was connected to the pattern electrode 16 and the external electrodes T5, and the second diode D2 was connected to the external electrodes T1 and T4. respectively, to obtain a composite switch device of the present invention of a size having length/width of 4.5 mm/3.2 mm and a thickness of 2 mm.

[0046] In the composite switch device thus obtained, the low pass filter circuit comprising the capacitors C2, C3 and C4 and the transmission line L3 was inserted between the anode portion of the first diode D1 and the first side portion of the shunt-connected transmission line L1.

[0047] A radio transceiver circuit of Fig. 3 is obtained by connecting the transmitting circuit Tx to the external electrode T3 via the capacitor C11, connecting the antenna ANT to the external electrode T5 via the capacitor C13, connecting the receiving circuit Rx to the external electrode T1 via the capacitor 12, connecting the first control circuit CONT1 to the external electrode T6 via the resistance R1, connecting the capacitor C14 to the external electrode T6 to form a path to ground, and connecting the second control circuit CONT2 to the external electrode T4 via the resistance R2.

[0048] The insertion loss at a frequency up to 5.5 GHz measured on the composite switch device obtained above is shown in Fig. 6A. An enlarged representation of the passband (0.5 to 1.5 GHz) of Fig. 6A is shown in Fig. 6B. As better seen from Fig. 6B, the composite switch device exhibited an insertion loss as low as 1 dB or less at a frequency range of 900 $\pm$ 250 MHz. Thus, the composite switch circuit of the preferred embodiment of the present invention is excellent in minimizing the insertion loss. Further, since the geometrical size can be reduce, only a small space is required in mounting the composite switch device of the present invention on a circuit board, thereby reducing the size of a radio transceiver such as a cellular radiotelephone. The composite switch device of the present invention is suitably used in a frequency range of about 800 MHz to several gigas of hertz.

[0049] In the above embodiment, the first and second transmission lines L1 and L2 were disposed between the first ground electrode 31 and the second ground electrode 32, and a substantial part of the switch circuit portion is disposed nearer to the mounting surface than the low pass filter circuit portion. With such a construction, the second ground electrode 32 forming the grounded capacitors C2 and C3 with the opposing ca-

pacitor electrodes 42 and 43 may have a lead portion, i.e. the external electrode T2 in the above embodiment, to be connected to a ground terminal of a circuit board on which the composite switch device is mounted. The external electrode T2 functions as a line electrode which may be considered as inductors L4 and L5, as shown by an equivalent circuit of Fig. 7, connected to the capacitors C2 and C3 in series. In such an equivalent circuit, harmonics can be effectively reduced by the series resonance between the capacitor C2 with the inductor L4, and the capacitor C3 with the inductor L5.

[0050] Therefore, in the present invention. it is preferable that the first and second transmission lines L1 and L2 are disposed between two ground electrodes, and that the capacitor of the low pass filter circuit is formed by the ground electrode above the transmission lines L1 and L2 and the capacitor electrode above and opposing the ground electrode. With such a construction, a miniaturized composite switch device with high performance can be obtained.

[0051] In the above embodiment, the transmission lines L1 and L2 were formed by spiral line electrodes printed on successively adjacent two dielectric substrates. By making the line electrodes spiral and partially overlapping the line electrodes on the tow dielectric substrates, the length of the line electrodes were made shorter.

[0052] Fig. 8 is a perspective view showing respective substrates constructing an integral multi-layer body disposed by another composite switch circuit 90 of the present invention. An equivalent circuit including the composite switch circuit 90 is shown in Fig. 9. The equivalent circuit of Fig. 9 is similar to that of Fig. 2, but in which an additional capacitor C5 is connected between the low pass filter circuit and the shunt-connected first transmission line Ll to form a shunt path to ground. The capacitor C5 is formed by a first ground electrode 31 on a dielectric substrate 21 and a capacitor electrode 45 on a dielectric substrate 22 which is connected to an external electrode T3. Since the third to ninth substrates from the bottom of Fig. 8 are respectively the same as the dielectric substrates 23 to 29 of Fig. 2, the description of these substrates are omitted here and in Fig. 8.

[0053] A composite switch device including the above composite switch circuit was produced in the same manner as described above, and was confirmed to have the same performance as in the above embodiment.

[0054] In place of the capacitor C5, an additional capacitor C6 may be connected as shown in Fig. 10. By incorporating the capacitor C5 shown in Fig. 9 or the capacitor C6 shown in Fig. 10, the line length of the first transmission line L1 can be effectively made shorter.

[0055] As described above, according to the present invention, a small composite switch circuit, which is incorporated with a low pass filter circuit, having a high performance can be obtained. In addition, a miniaturized composite switch device including the composite switch circuit can be obtained in a form of an integral multi-layer body by disposing the composite switch circuit on a plurality of dielectric substrates. The composite switch circuit and composite switch device of the present invention exhibit sufficient characteristics in a broad frequency range, much less insertion loss and a high suppression effect of harmonics.

[0056] While the present invention has been described in connection with a composite switch circuit operable to alternately connect the transmitting circuit to the antenna and the receiving circuit to the antenna, it is to be understood that the circuits to be switched by the composite switch circuit of the present invention are not specifically limited to the above circuits.

Claims

1. A composite switch circuit (30) for alternately and electrically connecting a first circuit (Tx) to a third circuit (ANT) or a second circuit (Rx) to said third circuit (ANT), which comprises:

   a first path interconnecting said first and third circuits (Tx, ANT), said first path including a first diode (D1) and a first transmission line (L1), a first side portion of said first diode (D1) being connected to said third circuit (ANT), and a first side portion of said first transmission line (L1) being connected to a node formed between said first circuit (Tx) and a second side portion of said first diode (D1) in a shunt configuration, a second path interconnecting said second and third circuits (Rx, ANT), said second path including a second transmission line (L2) and a second diode (D2), a first side portion of said second transmission line (L2) being connected to said third circuit (ANT), and a first side portion of said second diode (D2) being connected to a node formed between a second side portion of said second transmission line (L2) and said second circuit (Rx) in a shunt configuration, and

   a low pass filter circuit (LPF) disposed in said first path so as to interconnect the second side portion of said first diode (D1) and the first side portion of the shunt-connected first transmission line (L1).

2. The circuit of claim 1, wherein said first circuit is a transmitting circuit (Tx), said second circuit is a receiving circuit (Rx), and said third circuit is an antenna (ANT).

3. The circuit of claim 2, wherein a cathode portion of said first diode (D1) is connected to said transmitting circuit (Tx), an anode portion of said first diode (D1) is connected to said antenna (ANT), a cathode portion of said second diode (D2) is connected to

said receiving circuit (Rx), an anode portion of said second diode (D2) is grounded, and said low pass filter circuit (LPF) is connected between said cathode portion of said first diode (D1) and said shunt-connected first transmission line (L1).

4. The circuit of claim 2, wherein an anode portion of said first diode (D1) is connected to said transmitting circuit (Tx), a cathode portion of said first diode (D1) is connected to said antenna (ANT), an anode portion of said second diode (D2) is connected to said receiving circuit (Rx), a cathode portion of said second diode (D2) is grounded, and said low pass filter circuit (LPF) is connected between said anode portion of said first diode (D1) and said shunt-connected first transmission line (L1).

5. A composite switch device comprising the composite switch circuit (30) of any one of claims 1 to 4 disposed on a plurality of dielectric substrates of an integral multi-layer body (2), wherein at least said first transmission line (L1), second transmission line (L2) and a part of said low pass filter circuit (LPF) are disposed on at least one inner dielectric substrate (22-28) in said integral multi-layer body (2).

6. The device of claim 5, wherein said first and second diodes (D1, D2) are disposed on a top surface of said integral multi-layer body (2).

7. The device of claim 5 or 6, wherein said first and second transmission lines (L1, L2) disposed on inner dielectric substrates (22-28) in said integral multi-layer body (2) are positioned between two of at least two ground electrodes (31, 32) disposed on respective dielectric substrates (21, 25), and wherein a capacitor (C2) of said low pass filter circuit (LPF) is formed by an upper ground electrode (32) of said two electrodes sandwiching said first and second transmission lines (L1, L2) and an electrode (42) disposed on a dielectric substrate (26) positioned above and opposite to said upper ground electrode (32).

8. The device of claim 7, wherein electrodes (32, 42) forming plates of the capacitor (C2) of said low pass filter circuit (LPF) are respectively disposed on dielectric substrates (25, 26) positioned on the upper side of said first and second transmission lines (L1. L2) with respect to a mounting surface of said composite switch device.

9. The device of any oiie of claims 5 to 8, wherein said first and second transmission lines (L1, L2) are formed by electrode patterns (11-14) of spiral form.

10. The device of any one of claims 5 to 9, wherein a cathode portion of said first diode (D1) is connected to said transmitting circuit (Tx), an anode portion of said first diode (D1) is connected to said antenna (ANT), a cathode portion of said second diode (D2) is connected to said receiving circuit (Rx), an anode portion of said second diode (D2) is grounded, and said low pass filter circuit (LPF) is connected betweenn said cathode portion of said first diode (D1) and said shunt-connected first transmission line (L1).

11. The device of any one of claims 5 to 9, wherein an anode portion of said first diode (D1) is connected to said transmitting circuit (Tx), a cathode portion of said first diode (D1) is connected to said antenna (ANT), an anode portion of said second diode (D2) is connected to said receiving, circuit, a cathode portion of said second diode (D2) is grounded, and said low pass filter circuit (LPF) is connected between said anode portion of said first diode (D1) and said shunt-connected first transmission line (L1).

FIG. 1

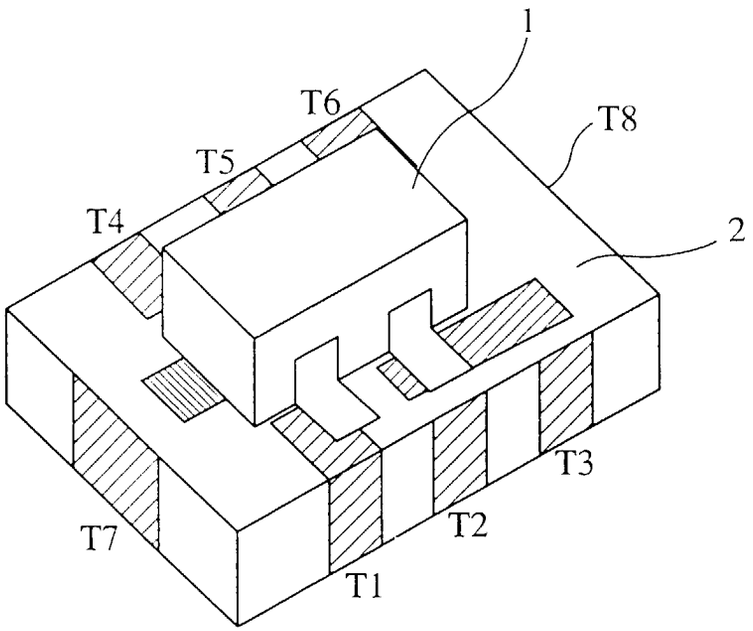

FIG. 2

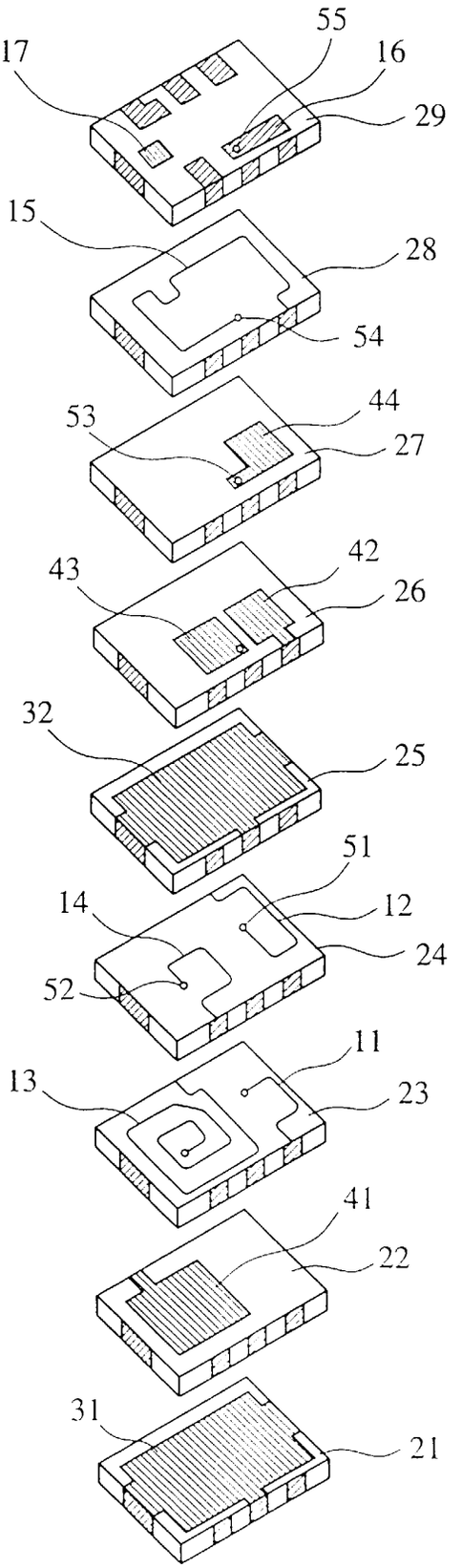
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FIG. 3

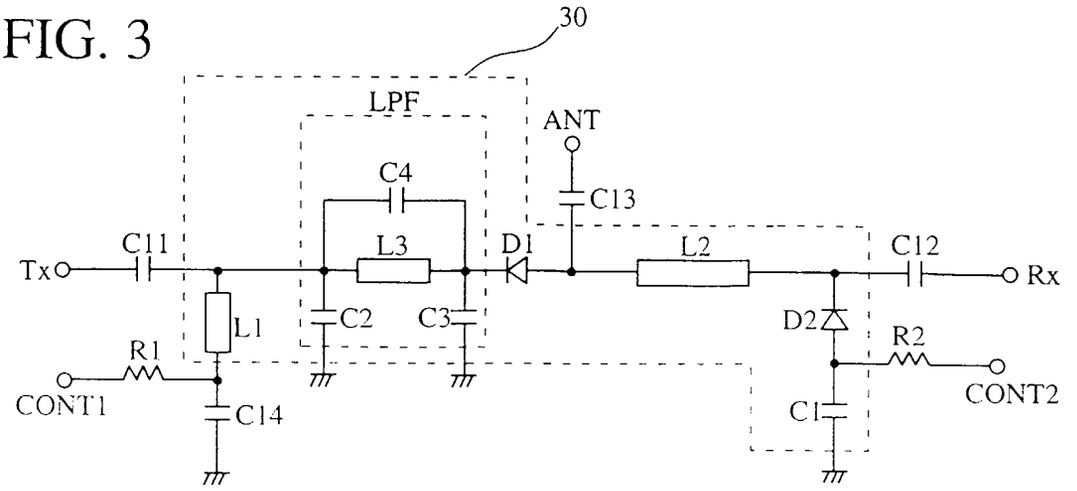


FIG. 4

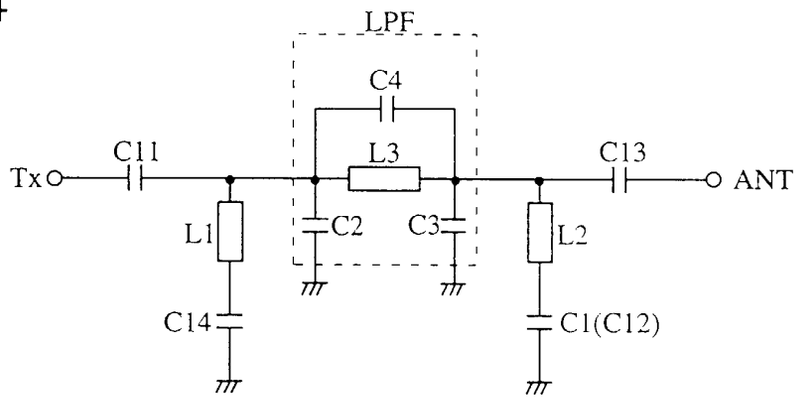


FIG. 5

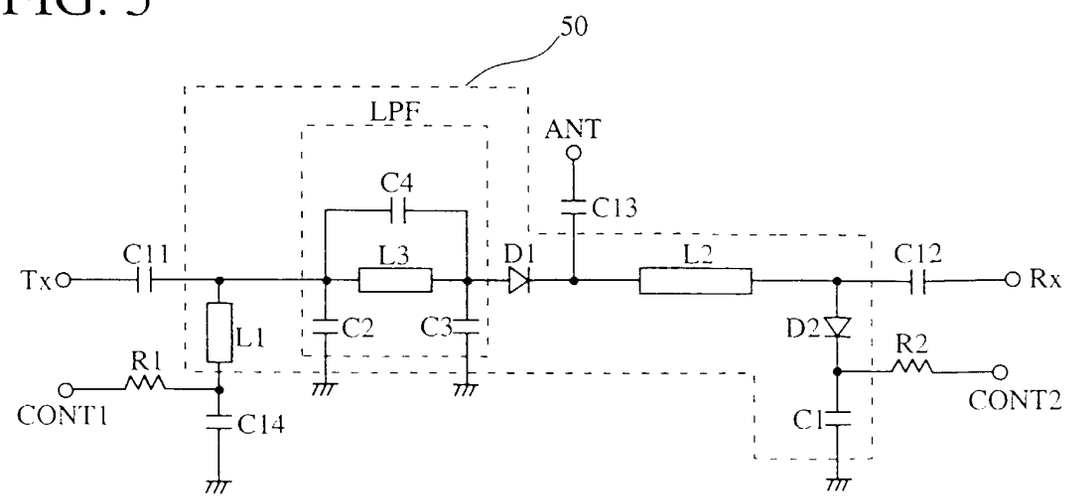


FIG. 6A

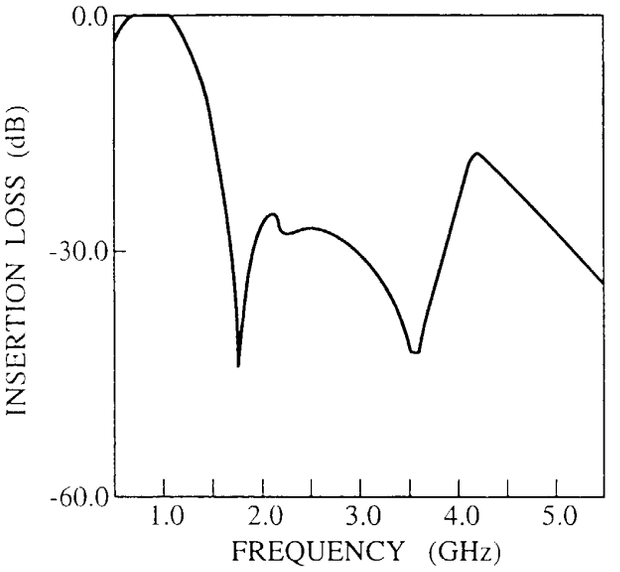


FIG. 6B

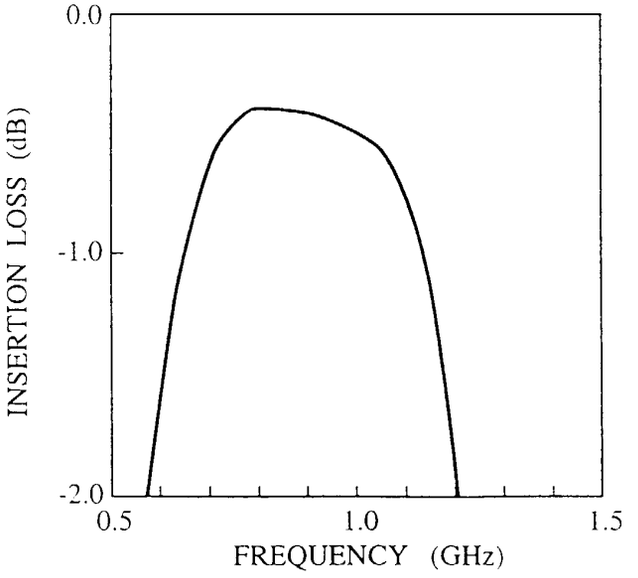


FIG. 7

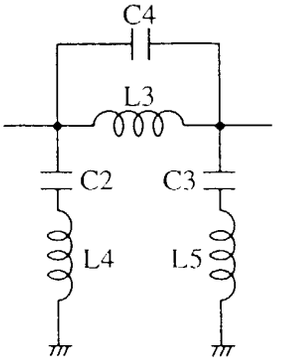


FIG. 8

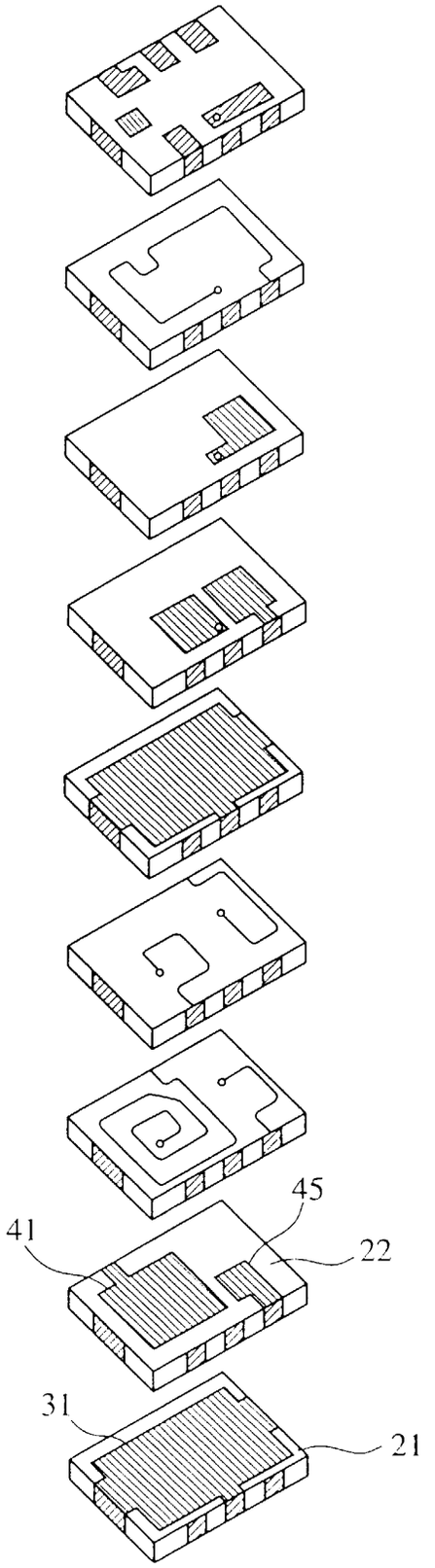


FIG. 9

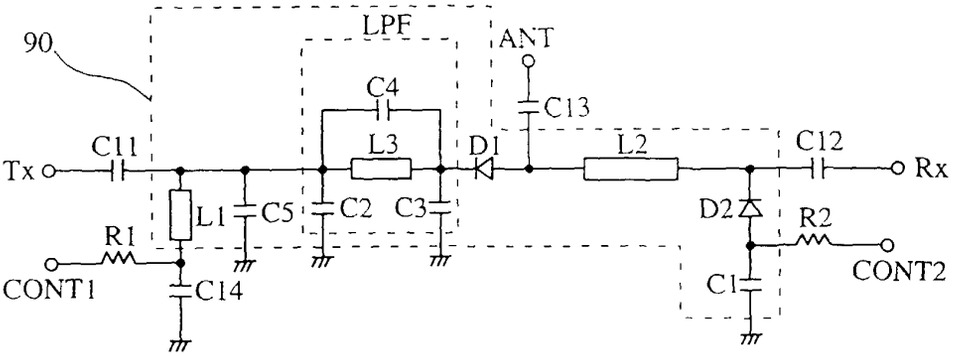


FIG. 10

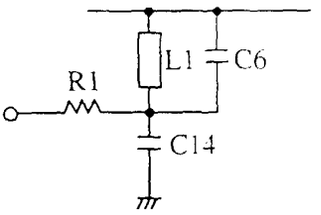


FIG. 11

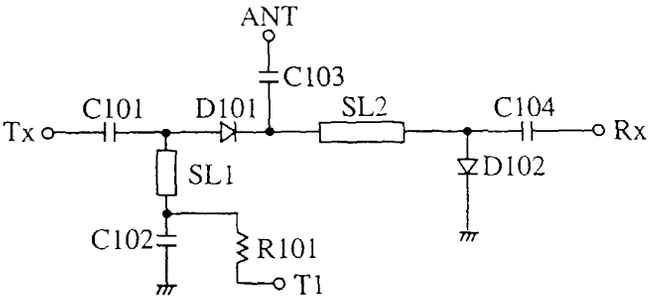


FIG. 12

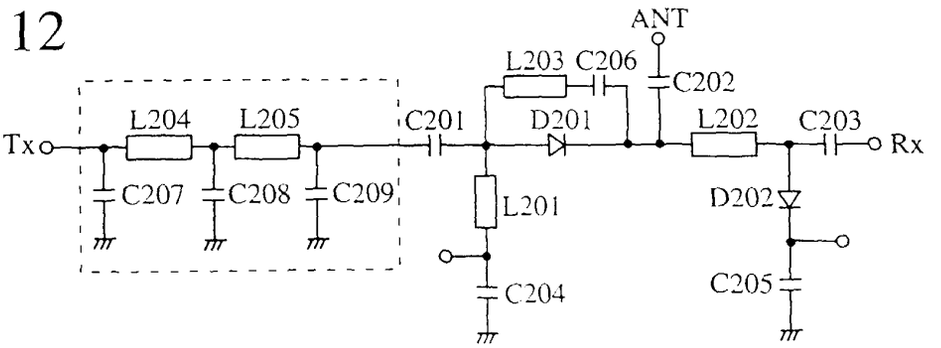
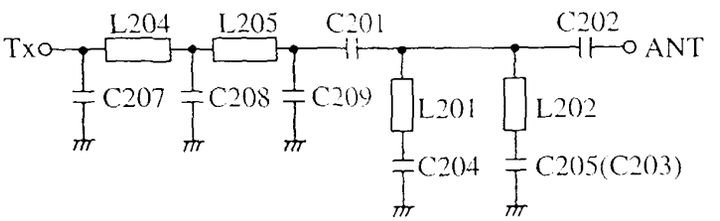


FIG. 13



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 11 2502

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	MANDAI H ET AL: "ADVANCED MULTI-LAYER CERAMIC SURFACE-MOUNT FUNCTIONAL COMPONENTS FOR TELECOMMUNICATIONS EQUIPMENT" PROCEEDINGS OF THE ELECTRONIC COMPONENTS AND TECHNOLOGY CONFERENCE, LAS VEGAS, MAY 21 - 24, 1995, no. CONF. 45, 21 May 1995, pages 247-250, XP002029547 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS * figure 4 * ---	1,2,4	H01P1/15
A	EP 0 784 384 A (TDK CORPORATION) 16 July 1997 * column 9, line 8 - line 42; figure 5 * ---	1	
D,A	EP 0 785 590 A (MURATA MANUFACTURING CO. LTD.) 23 July 1997 * column 4, line 25 - line 37; figure 1 * -----	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

H01P

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16 November 1998	Den Otter, A

CATEGORY OF CITED DOCUMENTS

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D : document cited in the application
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