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(54) LOW-PASS FILTER WITH DIRECTIONAL COUPLER AND PORTABLE TELEPHONE SET USING THE SAME
TIEFPASSFILTER MIT RICHTKOPPLER UND TRAGBARES TELEFON DAMIT
FILTRE PASSE-BAS A COUPLEUR DIRECTIF ET POSTE TELEPHONIQUE PORTATIF L'UTILISANT

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to low-pass filters with directional couplers suitable for the use in the transmission circuits of cellular phones used for mobile communications, and cellular phones employing such low-pass filters with directional couplers.

BACKGROUND OF THE INVENTION

[0002] Fig. 10 is a block diagram of the transmission system of an ordinary cellular phone. The monitor signal is coupled out from the power amplified by a power amplifier 1 through a capacity-coupling capacitor 2. An isolator 3 and then a low-pass filter 4 are connected in the system, and the signal is transmitted from the antenna 6 after removing second harmonic spurious and third harmonic spurious in the transmission system when a mode switch 5 is turned to the transmission side.

[0003] In the above configuration, however, the number of poles in the low-pass filter 4 may require to be increased to fully attenuate amplified second harmonic spurious and third harmonic spurious in the system. In addition, the isolator 3 connected for preventing reflection signals, regardless of the input position of the mode switch 5, results in a higher price.

DISCLOSURE OF THE INVENTION

[0004] The present invention offers a small and inexpensive low-pass filter with directional coupler and a cellular phone employing such low-pass filter for attenuating high-frequency band, in particular, second harmonic spurious and third harmonic spurious in the system.

[0005] A low-pass filter of present invention eliminates the use of an isolator and connects a stub line to the main transmission line of the directional coupler for coupling out the monitor signal. With this configuration, a specified frequency band can be attenuated with the same line length as directional couplers of the prior art, thereby reducing the number of components in the transmission system of cellular phones.

[0006] US 5,212,815 describes a low pass filter with directional coupler, having a main transmission line and a coupled line being disposed parallel to each other. Two stub lines are connected to the main transmission line to suppress either one or two undesired components of the radio signal, which may either be one or two harmonics of the basic frequency. The stub lines have a spacing of lambda-quarter or an integer multiple thereof of the undesired component of the radio signal. The filter stubs may be adjusted to provide rejection such as the third and fifth harmonics, or other undesired frequencies other than harmonically related to the fundamental frequency.

FIRST EXPLANATORY EMBODIMENT

[0007] A first explanatory embodiment of the present invention is explained with reference to drawings.

[0008] Fig. 1 shows a low-pass filter with directional coupler in the first explanatory embodiment, which is used in the 900 MHz frequency band. In Fig. 1, a main transmission line 105 which has terminals 101 and 102 at its ends and a sub transmission line 106 which has terminals 103 and 104 at its ends are disposed in parallel on a dielectric board 107 whose bottom face is a shield electrode. The main transmission line 105 and the sub transmission line 106 are electromagnetically coupled, and the terminal 104 terminates at 50 Ω to form a directional coupler. The dielectric board 107 consists of alumina and its bottom face is a shield electrode. Since the dielectric constant is small in the dielectric board 107, the characteristic impedance of the transmission lines can be made larger, thereby improving the characteristics of the directional coupler.

[0009] The terminals 101 and 102 are connected to stub lines 108 and 109 respectively. These transmission lines and stub lines can be formed using a range of methods including screen printing and film intaglio
transfer printing normally used for creating integrated circuit boards.

[0010] The operation of the low-pass filter with directional coupler as configured above is explained next.

[0011] An input impedance \(Z_i\) at the contact points of the stab lines 108 and 109 can be calculated as follows when the loss is ignored:

\[
Z_i = Z_0 \cdot \frac{(Z_1 + j Z_0 \tan \beta)}{(Z_0 + j Z_1 \tan \beta)}
\]

where

- \(Z_0\): Characteristic impedance of line;
- \(\beta\): Phase constant;
- \(l\): Line length; and
- \(Z_1\): Terminating impedance.

[0012] This means that the stab lines 108 and 109 act as a series resonance circuit depending on conditions of the characteristic impedance of line, terminating conditions, and line length, and their frequency characteristics include an attenuation pole. In addition, since the main transmission line 105 acts as an inductance, the present invention forms a low-pass filter having two attenuation poles with the passband frequency (hereafter referred to as \(\omega_0\)) where the line length of the main transmission line 105 is a quarter wavelength (hereafter referred to as \(\lambda/4\) wavelength).

[0013] The above explanatory embodiment offers a component with the function of a low-pass filter with attenuation poles in a specified frequency band in addition to the function of a directional coupler by connecting stab lines to both ends of the main transmission line of the conventional directional coupler and adjusting the characteristic impedance, terminating conditions, and line length of these stub lines.

[0014] There are two stub lines in the present embodiment, but one stub line is also acceptable. A single stub line allows the reduction of the area occupied by the component.

[0015] The length of at least one of the stab lines in this embodiment can also be set to the length which resonates with the double frequency of \(\omega_0\) (hereafter referred to as \(2\omega_0\)). This enables the suppression of the system's second harmonic spurious.

[0016] This exemplary embodiment can also be realized by setting the line length of one of the stab lines to resonate with \(2\omega_0\) and the other line length to resonate with the triple frequency of \(\omega_0\) (hereafter referred to as \(3\omega_0\)). This enables the suppression of second harmonic spurious and third harmonic spurious output.

[0017] The stub lines in this exemplary embodiment can be replaced with a meander line, spiral line, or stepped impedance line. This allows the reduction of the size of the low-pass filter with directional coupler without changing its characteristics.

[0018] The stub lines in this exemplary embodiment can also be replaced with an open stub line. In this case, the component will act as a resonator in which the line length of the stub line resonates with \(\lambda/4\). This enables shortening of the length of line required for forming the required attenuation pole. Here, two stub lines also show the characteristic of a capacitor in the \(\omega_0\) band, and the main transmission line and the two stab lines form a π-type 3-pole low-pass filter for improving attenuation characteristics in the high-frequency band.

[0019] The 900 MHz frequency band is used in this embodiment. However, the same effect can be achieved at any frequency for transmitting high frequency signals by the use of the present invention.

First exemplary embodiment

[0020] Fig. 2 shows a low-pass filter with directional coupler used in the 900 MHz frequency band in a first exemplary embodiment of the present invention. The low-pass filter with directional coupler in the first exemplary embodiment shown in Fig. 2 has basically the same configuration as that of the embodiment shown in Fig. 1. Detailed explanation is therefore omitted by giving the same numeric codes to the same parts.

[0021] Stub lines 208 and 209 of the low-pass filter with directional coupler in this exemplary embodiment are disposed parallel to the main transmission line 105 as shown in Fig. 2. The stub lines 208 and 209 are electromagnetically coupled to the main transmission line 105. The other configuration is the same as in the first explanatory embodiment.

[0022] The operation of the low-pass filter with directional coupler as configured above is explained next.

[0023] In the first explanatory embodiment, the main transmission line acts as an inductance, and both its ends are connected to the stub lines to act as a series resonance circuit for forming a low-pass filter with two attenuation poles. Since lines are formed on a board with low dielectric constant, the length of stub lines becomes relatively longer, resulting in a larger low-pass filter with directional coupler.

[0024] In this embodiment, stub lines 208 and 209 are disposed parallel to the main transmission line 105 and sub transmission line 106, which enables the realization of a low-pass filter with directional coupler with the same length as a directional coupler 210.

[0025] If a portion of the main transmission line 105 which is electromagnetically coupled with the stab line 208 consists of a two-port circuit employing a coupling transmission line as shown in Fig. 3 (a), its equivalent circuit will be as shown in Fig. 3 (b). In this case, the characteristic impedance \(Z_1\) of the main transmission line and the characteristic impedance \(Z_2\) of the stab line 208 are calculated as follows:

\[
Z_1 = \frac{(Z_a + Z_0)}{2}
\]
\[ Z_2 = \frac{Z_e}{Z_o} \cdot \frac{Z_e + Z_o}{2} \]

where

- \( Z_e \): Even mode impedance of coupling transmission line and
- \( Z_o \): Odd mode impedance of coupling transmission line.

**[0026]** As the coupling level of the coupling transmission line rises, generating a larger value for \( Z_e - Z_o \), the above formula dictates that the characteristic impedance \( Z_2 \) of the stub line 208 will increase, narrowing the bandwidth for the attenuation pole formed by the stub line 208. The bandwidth for the attenuation pole formed by the stub line 208 similarly narrows when the coupling level of the main transmission line 105 and the stub line 209 is increased.

**[0027]** Accordingly, in this exemplary embodiment, the bandwidth for the attenuation pole formed by the stub lines 208 and 209 can be controlled by changing the width of the main transmission line 105 and the stub line 208, and the distance between the two lines, or the line width of the main transmission line 105 and the stub line 209, and the distance between the two lines.

**[0028]** The 900 MHz frequency band is used in this exemplary embodiment. However, the same effect can be achieved at any frequency for transmitting high frequency signals by the use of the present invention.

**Second exemplary embodiment**

**[0029]** Fig. 4 shows a low-pass filter with directional coupler used in the 900 MHz band in a second exemplary embodiment of the present invention. The low-pass filter with directional coupler in the second exemplary embodiment shown in Fig. 4 has basically the same configuration as that of the first exemplary embodiment shown in Fig. 2. Detailed explanation is therefore omitted by giving the same numeric codes to the same parts.

**[0030]** In this exemplary embodiment, a capacitor 410 is connected to an end of the main transmission line 105, and capacitors 411 and 412 are connected to both ends of the sub transmission line 106. The other configuration is the same as in the first exemplary embodiment.

**[0031]** The operation of the low-pass filter with directional coupler as configured above is explained below.

**[0032]** In the embodiments of figures 1 and 2, the main transmission line acts as an inductance, and both its ends are connected to the stub lines to form a series resonance circuit which resonates with \( 2\omega_0 \) or \( 3\omega_0 \) to obtain the characteristics of a low-pass filter having two attenuation poles. In this case, the two stub lines also show the characteristics of a capacitor in the \( \omega_0 \) band, and form a \( \pi \)-type 3-pole low-pass filter. However, the capacity component of the two stub lines is not exactly the same. When the stub lines 208 and 209 are open stub lines as shown in Fig. 4, and each resonates with \( 2\omega_0 \) and \( 3\omega_0 \) respectively, their admittance is:

\[ Y = Y_0 \tan \beta_1 \] (whereas \( Y_0 = 1/Z_0 \)).

**[0033]** The admittance of an open stub line which resonates with a low frequency is higher than that of an open stub line which resonates with a higher frequency. Accordingly, the capacity component acting on the terminal 101 is larger than that on the terminal 102. Therefore, impedance is not matched in the low-pass filter with directional coupler of their embodiments of figures 1 and 2.

**[0034]** The second exemplary embodiment realizes a low-pass filter with matched impedance by adjusting the capacitors 410, 411, and 412, thereby correcting each capacity.

**[0035]** The capacity of the capacitor 410 is preferably be set to the value obtained by subtracting the capacity component of the stub line 209 from the capacity component of the stub line 208. The capacity of the capacitors 411 and 412 are also preferably set to the capacity component of the stub line 208. These settings allow the best impedance match at \( \omega_0 \).

**[0036]** In this exemplary embodiment, insufficient capacity of the stub line 209 is corrected by the capacitor 410 connected to the terminal 102. This can alternatively be achieved by making the line width of the stub line 209 wider than the stub line 208, instead of connecting the capacitor. This allows the number of components to be reduced, and also enables finer adjustment of the capacity.

**[0037]** The 900 MHz frequency band is used in this exemplary embodiment. However, the same effect can be achieved for any frequency for transmitting high frequency by the use of the present invention.

**Second exemplary embodiment**

**[0038]** Fig. 5 shows a low-pass filter with directional coupler used in the 900 MHz frequency band in a second exemplary embodiment. The low-pass filter with directional coupler in the embodiment shown in Fig. 5 has basically the same configuration as that of the embodiment shown in Fig. 1. Detailed explanation is therefore omitted by giving the same numeric codes to the same parts.

**[0039]** In this exemplary embodiment, the stub lines 513 and 514 are connected in parallel, and the stub lines 515 and 516 are also connected in parallel so that each pair forms a capacitor in the low-pass filter with directional coupler. The input impedance \( Z_i \) at the contact points of stub lines 513, 514, 515, and 516 is calculated as follows when the loss is ignored:
The frequency band of 900 MHz is used in this exemplary embodiment. However, the same effect can be achieved for any frequency for transmitting high frequency by the use of the present invention.

Third explanatory embodiment

Fig. 6 shows a low-pass filter with directional coupler used in the 900 MHz frequency band in a third explanatory embodiment. The low-pass filter with directional coupler in the embodiment shown in Fig. 6 has basically the same configuration as that of the embodiment shown in Fig. 5. Detailed explanation is therefore omitted by giving the same numeric codes to the same parts.

In the third explanatory embodiment, at least one of capacities connected to the main transmission line 105 is a stub line, and a chip capacitor is used for the remaining. The other configuration is the same as that of the embodiment shown in figure 5.

The operation of the low-pass filter with directional coupler as configured above is explained next.

In the embodiment of figure 5, the main transmission line 105 acts as an inductance. Stub lines are connected at both ends of the main line 105 to act as a series resonant circuit showing the capacity at the frequency \( \omega_0 \) for forming a low-pass filter having attenuation pole. However, for attenuating double frequency of 900 MHz on an alumina board, for example, the length of stub line becomes relatively long as 13.4 mm, resulting in larger low-pass filter with directional coupler.

In this embodiment, a chip capacitor 617 is connected to the main transmission line 105 as capacity. The length of applicable chip capacitor is 1 mm.

As mentioned above, this embodiment realizes a smaller low-pass filter with directional coupler by employing a stub line as one of capacities connected to the main transmission electrode line and a chip capacitor for the remaining capacity.

The 900 MHz frequency band is used in this embodiment. However, the same effect can be achieved at any frequency for transmitting high frequency signals by the use of the present invention.

Fourth explanatory embodiment

Fig. 7 shows a low-pass filter with directional coupler used in the 900 MHz frequency band in a fourth explanatory embodiment. The low-pass filter with directional coupler in the embodiment shown in Fig. 7 has basically the same configuration as that of the embodiment shown in Fig. 5. Detailed explanation is therefore omitted by giving the same numeric codes to the same parts.

In this embodiment, at least one of capacities connected to the main transmission line is a stub line, and an internal capacity 718 is used for the remaining. The other configuration is the same as that of the fourth
embodiment of figure 5.

[0059] The operation of the low-pass filter with directional coupler as configured above is explained next.

[0060] In the embodiment of figure 5, the main transmission line 105 acts as an inductance. Stub lines are connected at both ends of the main line 105 to act as a series resonant circuit showing the capacity at the frequency \( f_0 \) for forming a low-pass filter having attenuation pole. However, for attenuating double frequency of 900 MHz on an alumina board, for example, the length of stub line becomes relatively long as 13.4 mm, resulting in a larger low-pass filter with directional coupler.

[0061] In this embodiment, an internal capacitor 718 is connected to the main transmission line 105. The internal capacity can be formed with the length less than some millimeters.

[0062] As mentioned above, this embodiment realizes a smaller low-pass filter with directional coupler by employing a stub line as one of capacities connected to the main transmission line and an internal capacitor for the remaining capacity.

[0063] The 900 MHz frequency band is used in this embodiment. However, the same effect can be achieved at any frequency for transmitting high frequency signals by the use of the present invention.

Fifth explanatory embodiment

[0064] Fig. 8 shows a low-pass filter with directional coupler used in the 900 MHz frequency band in a fifth explanatory embodiment. The low-pass filter with directional coupler in the embodiment shown in Fig. 8 has basically the same configuration as that of the embodiment shown in Fig. 1. Detailed explanation is therefore omitted by giving the same numeric codes to the same parts.

[0065] In this embodiment, a stub line connected to the main transmission line is an internal stub line 819 inside the board. The other configuration is the same as that of the embodiment of figure 1.

[0066] The operation of the low-pass filter with directional coupler as configured above is explained next.

[0067] Conditions of a stub line formed on the board using methods such as screen printing and concave printing normally used for creating integrated circuit boards is difficult to be adjusted due to limitations in formation methods. In addition, the line is likely to be affected by external factors after formation. Since the stub lines in the present invention are finely adjusted by its characteristics impedance, terminating conditions, and line length, characteristics of this type of stub line may not be stabilized.

[0068] The fifth explanatory embodiment offers a low-pass filter with directional coupler which maintains the initial condition of the line when it is formed, and prevents external influence by connecting a stub line formed inside the board to the main transmission line 105.

[0069] One internal stub line is provided in this embodiment. It will be apparent that two or more internal stub lines can be provided. In this case, characteristics of low-pass filter with directional coupler can be further stabilized.

[0070] In this embodiment, a stub line is provided inside the board, but the entire low-pass filter with directional coupler can also be provided inside. It will further stabilize characteristics of low-pass filter with directional coupler.

[0071] The 900 MHz frequency band is used in this embodiment. However, the same effect can be achieved at any frequency for transmitting high frequency signals by the use of the present invention.

[0072] Fig. 9 shows an output circuit of the transmission system in a cellular phone employing a low-pass filter with directional coupler. The low-pass filter with directional coupler employed can be one of the embodiments.

[0073] In Fig. 9, the terminal 101 is connected to a power amplifier 1, and the terminal 102 is connected to a mode switch 5. The terminal 103 is used as a monitor terminal, and the terminal 104 is left as it is terminating at 50\( \Omega \).

[0074] The operation of the output circuit of the transmission system in the cellular phone as configured as above is explained below.

[0075] The power amplifier 1 amplifies the system signal, and the signal is transmitted from an antenna 6 through a low-pass filter with directional coupler 7 and the mode switch 5. Here, high-frequency band in the system, particularly second harmonic spurious and third harmonic spurious are attenuated by the low-pass filter with directional coupler 7, and is not transmitted to the antenna. The monitor signal can also be coupled out by the directional coupler.

[0076] This exemplary embodiment offers a smaller and more inexpensive cellular phones by the use of a low-pass filter with directional coupler of the present invention which enables to reduce the number of components in the output circuit of the transmission system in cellular phones.

INDUSTRIAL APPLICABILITY

[0077] The present invention provides a component with an additional function of a low-pass filter having an attenuation pole at a specified frequency band without changing the line length by connecting a stab line to a main transmission line of a directional coupler. The bandwidth of the attenuation pole can also be controlled by electromagnetically connecting the stab line and the main transmission line. Impedance of the low-pass filter with directional coupler can also be matched by grounding both ends of the main and sub transmission lines through a capacitor. The use of the low-pass filter with directional coupler of the present invention in the output circuit of the transmission system in the cellular phone
enables to reduce the number of components and realizes a smaller and inexpensive cellular phones. The present invention provides a function of a low-pass filter for attenuating required frequency in addition to the function of directional coupler by dividing at least one of capacities and providing at least one stab line thereof. The width of the stab line can be narrowed by dividing the capacity, realizing smaller low-pass filter with directional coupler. The number of components can be reduced and a smaller and inexpensive cellular phone can be realized by adopting the low-pass filter with directional coupler of the present invention in the transmission circuit of the cellular phone.

Reference numerals for drawings

[0078]

1 Power amplifier
2 Capacity-coupling capacitor
3 Isolator
4 Low-pass filter
5 Mode switch
6 Antenna
7 Low-pass filter with directional coupler
101 - 104 Terminal
105 Main transmission line
106 Sub transmission line
107 Dielectric board
108, 109 Stub line
208, 209 Stub line
210 Directional coupler
410 - 412 Capacitor
513 - 516 Stub line
617 Chip capacitor
718 Internal capacitor
819 Internal stub line

Claims

1. Low-pass filter with directional coupler, the directional coupler having a main transmission line (105) and an electromagnetically coupled line (106), both transmission lines being disposed parallel to each other on the same dielectric board (107), a stub line being connected to one end of the main transmission line (105) or two stub lines (108, 109; 208, 209; 513 - 516) being connected to different ends (101, 102) of the main transmission line (105), the stub line being adapted to have a resonance frequency at a specified frequency band and in case of two stub lines these stub lines have resonance frequencies at different frequency bands, preferably at the second and/or third harmonic of the fundamental frequency ($\omega_0$) of the main transmission line (105), wherein the stub lines (208, 209) are electromagnetically coupled to the main transmission line (105) in that they are disposed in lengthwise direction to the main transmission line (105).

2. Low-pass filter as defined in claim 1, wherein the harmonics are double ($\omega_1$) and triple ($\omega_2$) of the fundamental frequency ($\omega_0$).

3. Low-pass filter as defined in any of claims 1 - 2, wherein the stub lines (108, 109; 208, 209; 513 - 516) have line lengths to resonate with at least one of the selected harmonics ($\omega_1$, $\omega_2$) of the fundamental frequency ($\omega_0$).

4. Low-pass filter as defined in any of claims 1 - 3, wherein capacitors (410, 411, 412) are connected between a terminal (102) connected to said stub line (209) which resonates with the triple frequency and GND, and between each terminal (103, 104) of the coupled transmission line (106) of the directional coupler and GND.

5. Low-pass filter as defined in any of claims 1 - 4, wherein said stub line is one of a meander line (308), spiral line (408) or stepped impedance line (508).

6. Low-pass filter as defined in any of claims 1 - 5, wherein the line width of the stub line (209) which resonates with the triple frequency is broader than the width of the stub line (208) which resonates with the double frequency.

7. Low-pass filter as defined in any of claims 1 - 6, wherein the stub line (108, 109; 208, 209; 513 - 516) is an open stub line.

8. Low-pass filter as defined in any of claims 1 - 7, wherein the stub line (819) is disposed inside the board (107).

9. Low-pass filter as defined in any of claims 1-8, wherein a chip component (617) is connected to one end (101) of the main transmission line (105), said chip component having a capacitive component.

10. Low-pass filter as defined in any of claims 1-8, wherein an internal capacitive component (718) is connected to one end (101) of the main transmission line (105).

11. A cellular phone including a low-pass filter with a directional coupler as defined in any of claims 1 - 10.

Patentansprüche

1. Tiefpassfilter mit Richtkoppler, wobei der Richt-
Revendications

1. Filtre passe-bas à coupleur directif, le coupleur directif ayant une ligne de transmission principale (105) et une ligne couplée électromagnétiquement (106), les deux lignes de transmission étant disposées parallèlement l'une à l'autre sur la même carte diélectrique (107), un tronçon de ligne étant connecté à une extrémité de la ligne de transmission principale (105) ou deux tronçons de ligne (108, 109; 208, 209; 513 à 516) étant connectés à des extrémités différentes (101, 102) de la ligne de transmission principale (105), le tronçon de ligne étant adapté pour avoir une fréquence de résonance dans une bande de fréquences spécifiée et, dans le cas de deux tronçons de ligne, ces tronçons de ligne ont des fréquences de résonance dans des bandes de fréquences différentes, de préférence sur la deuxième et/ou sur la troisième harmonique de la fréquence fondamentale (ω₀) de la ligne de transmission principale (105), dans lequel les tronçons de ligne (208, 209) sont couplés électromagnétiquement à la ligne de transmission principale (105) parce qu'ils sont disposés dans la direction de la longueur par rapport à la ligne de transmission principale (105).

2. Filtre passe-bas comme défini dans la revendication 1, dans lequel les harmoniques sont le double (ω₁) et le triple (ω₂) de la fréquence fondamentale (ω₀).

3. Filtre passe-bas comme défini dans l'une quelconque des revendications 1 et 2, dans lequel les tronçons de ligne (108, 109; 208, 209; 513 à 516) ont des longueurs de ligne pour résonner sur au moins une des harmoniques sélectionnées (ω₁, ω₂) de la fréquence fondamentale (ω₀).

4. Filtre passe-bas comme défini dans l'une quelcon-
que des revendications 1 à 3, dans lequel des condensateurs (410, 411, 412) sont connectés entre une borne (102), connectée à un tronçon de ligne (209) qui résonne à la fréquence triple, et la masse, et entre chaque borne (103, 104) de la ligne de transmission couplée (106) du coupleur directif et la masse.

5. Filtre passe-bas comme défini dans l'une quelconque des revendications 1 à 4, dans lequel la largeur de la ligne du tronçon de ligne (209) qui résonne à la fréquence triple est supérieure à la largeur du tronçon de ligne (208) qui résonne à la fréquence double.

6. Filtre passe-bas comme défini dans l'une quelconque des revendications 1 à 5, dans lequel le tronçon de ligne est une parmi une ligne en méandre (308), une ligne en spirale (408) ou une ligne d'impédance à palier (508).

7. Filtre passe-bas comme défini dans l'une quelconque des revendications 1 à 6, dans lequel le tronçon de ligne (108, 109; 208, 209; 513 à 516) est un tronçon de ligne ouvert.

8. Filtre passe-bas comme défini dans l'une quelconque des revendications 1 à 7, dans lequel le tronçon de ligne (819) est disposé à l'intérieur de la carte (107).

9. Filtre passe-bas comme défini dans l'une quelconque des revendications 1 à 8, dans lequel un composant pour montage en surface (617) est connecté à une extrémité (101) de la ligne de transmission principale (105), ledit composant pour montage en surface ayant un composant capacitif.

10. Filtre passe-bas comme défini dans l'une quelconque des revendications 4 à 8, dans lequel un composant capacitif interne (718) est connecté à une extrémité (101) de la ligne de transmission principale (105).

11. Téléphone cellulaire incluant un filtre passe-bas avec un coupleur directif comme défini dans l'une quelconque des revendications 1 à 10.
FIG. 4
FIG. 9
FIG. 10