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(54) Oscillator and frequency synthesizer and communication apparatus using the oscillator
Oszillator sowie den Oszillator verwendende Frequenzsynthesizer und Kommunikationsgeräte
Oscillateur et synthétiseur de fréquence et appareil de communication utilisant ledit oscillateur

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Description

This invention relates to an oscillator and a frequency synthesizer and a communication apparatus using the oscillator.

There are two types of oscillator for oscillating at a high frequency band such as a quasi-microwave band or the like, namely, the first type of the oscillator directly oscillates at the desired frequency and the second type of the oscillator oscillates at a low frequency and a frequency-up converter coupled to the oscillator provides frequency-up outputs. The second type of the oscillators are frequently used due to easiness in designing and a reduction of a consumed current. Frequency synthesizer and a communication apparatus using such a prior art oscillator are also known.

Hereinafter, a prior art high frequency band oscillator will be described.

Fig. 20 is a block diagram of the prior art high frequency band oscillator, on which the preamble of claim 1 is based.

In Fig. 20, numeral 1 denotes a ring oscillator numeral 2 denotes an oscillation portion comprising a negative resistance active circuit using transistors or the like, and numeral 3 denotes a coupling capacitance for coupling between the ring oscillator 1 and the oscillation portion 2. Numeral 5 denotes a frequency-up converter comprising non-linear elements such as transistors, numeral 6 denotes a bandpass filter (BPF) for outputting a frequency-up output of the frequency-up converter and attenuating unnecessary waves, numeral 7 is an output terminal, and point A is a coupling point between the ring oscillator 1 and oscillation portion 2.

An operation of the prior art high frequency band oscillator having the structure mentioned above will be described.

At first, the oscillator 4 oscillates at a frequency determined by an electrical length of the ring oscillator 1 and a circuit constant of the oscillation portion 2. Because the frequency-up converter 5 comprises non-linear elements such as transistors and has a function generating a higher harmonic wave of the input signal, a double frequency output is obtained from the output of the oscillator 4 by the frequency-up converter 5. However, since an output level of a basic wave is generally larger than that of the double frequency output, it is necessary that a BPF 6 for attenuating the basic waves is connected at a rear stage of the frequency-up converter 5. Therefore, the double frequency waves can be obtained from the output terminal 7.

On the other hand, a frequency synthesizer comprising the ring resonator, and the oscillation portion and a phase synchronizing circuit is known. In such a phase synchronizing circuit, it is necessary to divide the output of the oscillator into a signal for an input of a phase synchronizing circuit and another signal for the external output.

Such a prior art frequency synthesizer will be described more specifically.

Fig. 21 is a block diagram of a prior art frequency synthesizer.

In Fig. 21, since elements denoted by numerals 1 to 4 and 7 and the point A are the same as Fig. 20, the detailed description is omitted. Numeral 8 denotes a distributor for outputting distribution outputs with a isolation degree therebetween kept, numeral 9 denotes a phase synchronizing portion having a frequency divider, a phase comparator, and a charge pump or the like, and numeral 10 denotes a loop filter for feeding back an output of the phase synchronizing portion 9 with high frequency components removed. Numeral 11 is a reference signal generator, and numeral 12 denotes a phase synchronizing circuit comprising the phase synchronizing portion 9, the loop filter 10, and the reference signal generator 11.

An operation of this prior art frequency synthesizer will be described.

The output of the distributor 8 is phase-compared by the phase synchronizing portion 9 with the reference signal from the reference signal generator 11. The phase synchronizing portion 9 supplies a synchronizing signal to the oscillation portion 2 through the loop filter 10 with unnecessary high frequency component removed wherein the outputs of the distributor 8 should have a sufficient isolation degree.

However, the prior art oscillator shown in Fig. 20 has problems that the circuit scale becomes larger and the consumed current becomes large because the frequency-up converter and the prior art frequency synthesizer shown in Fig. 21 have problems that the circuit scale is large and the consumed current is large because the distributor are necessary in addition to the oscillator.

Other prior art oscillators with ring resonators are known e.g. from EP-A-0 527 470 or US-A-5 289 139.

SUMMARY OF THE INVENTION

The aim of the present invention is to provide an improved oscillator and an improved frequency synthesizer and an improved communication apparatus using the oscillator.

According to this invention, there is provided an oscillator comprising:

a ring resonator; and
an oscillation circuit having a negative resistance active circuit coupled to a first point on said ring resonator for oscillating at a fundamental oscillation frequency and resonating said resonator, characterized by:
a output terminal, coupled to a second point on said ring resonator where a voltage is substantially zero with respect to said fundamental oscillation frequency when said ring resonator resonates, for outputting a second harmonic frequency signal.
More specifically, the voltage output of the oscillator is maximum at the coupling point between the ring resonator and the ring oscillator shows a sinusoidal distribution of voltages along the line of the ring resonator, so that the voltage at a certain point on the ring resonator is zero with respect to the fundamental oscillation frequency but is a maximum at the secondary harmonic frequency. Therefore, it is possible to obtain the secondary harmonic frequency output from this point and to suppress the fundamental harmonic component without a bandpass filter.

According to some embodiments of this invention the ring resonator has points A to D equidistantly dividing the ring resonator, first and second oscillation circuits coupled to the points A and B respectively, and first and second grounding capacitors having capacitance equivalent to those of the first and second oscillation circuits. Therefore, two independent oscillators which do not affect each other are provided with a single resonator.

In the invention, grounding capacitors or a resonant capacitor may be further provided to miniaturize the oscillator. Variable capacitances may be provided to prevent the point from moving with a change in the controlled oscillation frequency. Frequency synthesizers and communication apparatus including the oscillators of the invention are also provided.

In the oscillators of the invention, the oscillation circuit may have a control input for receiving a control signal and oscillates at the oscillation frequency controlled in accordance with the control signal.

According to this invention, there is provided a communication apparatus using the two output oscillator wherein the first output is used for the local signal of the transmission band and the second output is used for the local signal of the receiving band of a radio signal. According to this invention, there is also provided a communication apparatus using the two output oscillator wherein the first output is used in a first frequency converter for frequency converting of a received radio signal and the second output is used for second frequency converter for frequency converting of an output of the first frequency converter before detection processing.

The object and features of the present invention will become more readily apparent from the following detailed description of exemplary embodiments and the accompanying drawings, in which:

Fig. 1 is a schematic drawing of an oscillator of a first embodiment;
Fig. 2 is an illustration of a voltage distribution on a ring resonator shown in Fig. 1;
Fig. 3 is a schematic drawing of an oscillator of a second embodiment of this invention;
Fig. 4 is a schematic drawing of an oscillator of a third embodiment of this invention;
Fig. 5 is a schematic drawing of an oscillator of a fourth embodiment of this invention;

Figs. 6A and 6B are schematic drawings of oscillators of first and second examples of a fifth embodiment;
Figs. 7A and 7B are schematic drawings of an oscillator of first and second examples of a sixth embodiment;
Fig. 8 is a schematic drawing of a frequency synthesizer of a seventh embodiment;
Fig. 9 is a schematic drawing of an oscillator of an eighth embodiment;
Fig. 10 is a graphic diagram of an eighth embodiment showing an output level change with respect to an electrical length from a coupling point;
Figs. 11A and Fig. 11B are schematic drawings of oscillators of first and second examples of a ninth embodiment;
Fig. 12 is a schematic drawing of an oscillator of a tenth embodiment;
Fig. 13 is a schematic drawing of an oscillator of an eleventh embodiment;
Fig. 14 is a schematic drawing showing a main portion of an oscillator of a twelfth embodiment;
Fig. 15 shows isolation characteristics of eleventh and twelfth embodiments;
Fig. 16 is a schematic drawing showing a main portion of an oscillator of a thirteenth embodiment;
Fig. 17 is a schematic drawing showing a main portion of an oscillator of a fourteenth embodiment;
Fig. 18 is a schematic drawing showing a main portion of an oscillator of a fifteenth embodiment;
Fig. 19 is a schematic drawing of a frequency synthesizer of a sixteenth embodiment;
Fig. 20 is a block diagram of a prior art high frequency band oscillator; and
Fig. 21 is a block diagram of a prior art frequency synthesizer;
Fig. 22 is a block diagram of an example circuit using the oscillator of the fifteenth embodiment; and
Fig. 23 is a block diagram of an example of a circuit using the frequency synthesizer of the sixteenth embodiment.

The same or corresponding elements or parts are designated with like references throughout the drawings.

DETAILED DESCRIPTION OF THE INVENTION

(EMBODIMENT 1)

Hereinbelow, a first embodiment of this invention will be described with reference to drawings.

Fig. 1 is a schematic drawing of an oscillator of the first embodiment. Fig. 2 is an illustration of a voltage distribution on a ring resonator shown in Fig. 1. The oscillator of the first embodiment comprises a (dielectric) ring resonator 1, an oscillation circuit 2 for generating an oscillation signal having an oscillation (fundamental) fre-
frequency $\Omega_0$, a coupling capacitor $C_3$ for coupling the oscillation circuit 2 to the ring resonator 1 through a coupling point $A$ on the ring resonator 1, and an output capacitor $C_7$ for supplying a secondary harmonic frequency output (resonant signal) from a point $B$ on the ring resonator 1 to an output terminal 7. The point $B$ on the ring resonator 1 shows zero voltage with respect to the fundamental oscillation frequency $\Omega_0$ but a maximum voltage with respect to the double frequency $2\Omega_0$.

An operation of the oscillator having the structure mentioned above.

At first, the oscillation circuit 2 oscillates at the fundamental frequency $\Omega_0$ determined by an electrical length of the ring resonator 1 and a circuit constant of the oscillation circuit 2 and the point $A$ shows the maximum voltage with respect to the fundamental component frequency $\Omega_0$ and a sinusoidal voltage distribution occurs with respect to the fundamental frequency $\Omega_0$ as shown in Fig. 2. In this voltage distribution, there is a point $B$ where the voltage is zero with respect to the fundamental frequency $\Omega_0$ but is maximum with respect to the secondary harmonic frequency $2\Omega_0$. The point $B$ is apart from the coupling point $A$ by a distance less than a quarter of the line length of the ring resonator 1. Therefore, the output capacitor $C_7$ can output a resonant signal of the secondary harmonic frequency $2\Omega_0$ with the fundamental frequency suppressed. That is, even order harmonic components are supplied with odd order components suppressed.

As mentioned above, according to this embodiment, a high frequency band oscillator is provided with a simple circuit structure and low current consumption because a frequency-up converter which was conventionally connected to an output of the oscillator becomes unnecessary.

In this embodiment, the oscillation circuit 2 is used for resonating the ring resonator 1. However, the oscillation circuit 2 has a control input $I_{2a}$ for receiving a frequency control signal and can change the oscillation frequency in accordance with a voltage of the frequency control signal. If the oscillation circuit oscillates at a fixed frequency, a fixed voltage is supplied to the control input $I_{2a}$. The oscillation circuit 2 has an oscillation signal output $I_{2b}$ for supplying an oscillation signal to a phase synchronization circuit in a frequency synthesizer. Therefore, this oscillator can be used for a frequency synthesizer wherein a voltage controlled oscillation is performed. However, these terminals $I_{2a}$ and $I_{2b}$ may be omitted in the specification except embodiment of the frequency synthesizer.

(EMBODIMENT 2)

Hereinbelow, a second embodiment of this invention will be described with reference to a drawing.

Fig. 3 is a schematic drawing of an oscillator of the second embodiment of this invention. The basic structure is similar to the first embodiment and the difference between first and second embodiments is that a capacitor $C_8$ coupled to the ground is provided at a point $C$ apart from the coupling point $A$ by a half of line length of the ring resonator 1.

An operation of the oscillator of the second embodiment will be described.

The basic operation is the same as the first embodiment. The difference is in that a position of the point $B$ where the voltage with respect to the fundamental frequency $\Omega_0$ is zero but the voltage is maximum with respect to the secondary harmonic frequency $2\Omega_0$ can be controlled in accordance with the value of the capacitance for grounding provided at the point $C$. Particularly, if the capacitance value of the capacitor $C_8$ for grounding is equivalent to a capacitance value of the oscillation portion 2 viewed from the point $A$ of the ring resonator 1, the point $B$ is located at a middle point between the points $A$ and $C$ on the ring resonator 1.

As mentioned above, according to this embodiment, a high frequency band oscillator is provided with a simple circuit structure and a low current consumption because a frequency-up converter which would be connected to an output of the oscillator is unnecessary by obtaining the output of the oscillator from the point $A$ on the ring resonator where the voltage is zero with respect to the oscillation frequency as shown in Fig. 3.

(EMBODIMENT 3)

Hereinbelow a third embodiment of this invention will be described with reference to Fig. 4.

Fig. 4 is a schematic drawing of an oscillator of the third embodiment of this invention. The basic structure is similar to the first embodiment and the difference between first and third embodiment is in that outputs at two points $B$ and $D$ on the ring resonator where the voltages is zero with respect to the fundamental harmonic frequency $\Omega_0$ and are maximum with respect to the secondary frequency $2\Omega_0$ are outputted through output capacitors $C_1$ and $C_2$ with the outputs in-phase combined.

An operation of the oscillator of the third embodiment will be described.

The basic operation is the same as the first embodiment. The difference is in that the positions of the points $B$ and $D$ show the maximum voltages with respect to the secondary harmonic frequency and a phase difference each other by 360°, that is, in-phase, so that the secondary harmonic component can be obtained with large intensity by in-phase combining through the output capacitors $C_1$ and $C_2$. That is, even order harmonic components can be obtained with larger intensity than the first embodiment. On the other hand, the fundamental component and the odd order harmonic components are suppressed similarly to the first embodiment.

As mentioned above, according to this embodiment, a high frequency band oscillator is provided with a simple circuit structure and a low current consumption because a frequency-up converter which would be con-
nected to an output of the oscillator is unnecessary and a larger output level of the secondary harmonic component is provided from two points B and D on the ring resonator where the voltages are zero with respect to the oscillation frequency as shown in Fig. 4.

Fig. 4 shows only an example where output capacitors 13 and 15 are used as the in-phase combining means and other in-phase combining circuits can be used similarly.

(EMBODIMENT 4)

Hereinbelow a fourth embodiment of this invention will be described with reference to Fig. 5.

Fig. 5 is a schematic drawing of an oscillator of the fourth embodiment of this invention. The basic structure of the oscillator of the fourth embodiment is similar to the third embodiment and the difference between the fourth embodiment and the third embodiment is in that a grounding capacitor 14 is provided at a point C apart from the coupling point A by a half of the line length of the ring resonator 1.

An operation of the oscillator having the structure of the fourth embodiment will be described.

The basic operation is similar to the third embodiment. The difference is in that the positions of the points B1 and D1 where the voltages are zero with respect to the fundamental frequency f0 and are maximum with respect to the secondary harmonic frequency 2f0 can be controlled. Particularly, if a capacitance value of the grounding capacitor 14 is equivalent to the capacitance value of the oscillation circuit 2' viewed from the point A, these two points B1 and D1 are at middle points of points A and C on the ring resonator 1.

As mentioned above, according to this embodiment, a high frequency band oscillator is provided with a simple circuit structure and a low current consumption because a frequency-up converter which would be connected to an output of the oscillator is unnecessary and a larger output level of the double frequency signal is provided by obtaining the outputs of the oscillator from two points B1 and D1 on the ring resonator 1 where the voltages are zero with respect to the oscillation frequency through in-phase combining.

Moreover, Fig. 5 shows only an example of this embodiment. That is, the output capacitors 13 and 15 are used as the in-phase combining means. However, other in-phase combining circuits can be used for this embodiment.

(EMBODIMENT 5)

Hereinbelow a fifth embodiment of this invention will be described with reference to drawings. The fifth embodiment is provided to miniaturize the ring resonator 1.

Fig. 6A is a schematic drawing of an oscillator of a first example of the fifth embodiment. The basic structure of the oscillator of this first example of the fifth embodiment is similar to the third embodiment and the difference between the first example of the fifth embodiment and the third embodiment is in that a resonant capacitor 16 is connected between the coupling point A and the coupling point C apart from the coupling point A by a half of the line length of the ring resonator 1 and grounding capacitors 17 and 18 having the same capacitance value are connected to two points B and D on the ring resonator 1 where the voltage is zero with respect to the fundamental frequency f0.

Fig. 6B is a schematic drawing of an oscillator of a second example of the fifth embodiment of this invention. The basic structure of this second example of the fifth embodiment is similar to the third embodiment and the difference between the second example of the fifth embodiment and the third embodiment is in that the coupling point A and the ground is coupled by a capacitor 19, the point C apart from the coupling point A by the half of the line length of the ring resonator 1 and the ground is coupled by a grounding capacitor 20 having the same capacitance value as the grounding capacitor 19, and capacitors 17 and 18 having the same capacitance value are connected between the ground and two points B and D on the ring resonator 1 where the voltage is zero with respect to the fundamental frequency f0. This structure provides that capacitances are symmetrically (with balance) provided with respect to the two points A and C where voltages are maximum with respect to the fundamental frequency f0.

Operations of the oscillator of the first and second examples of the fifth embodiment will be described.

An electrical length of the ring resonator 1 of fifth embodiment for providing the oscillation output having the same frequency f0 as the first to fourth embodiments is shorter than first to fourth embodiments because the oscillator oscillates at the frequency determined by the electrical length of the ring resonator 1, a circuit constant of the oscillation portion 2, and resonating capacitance 16 or the grounding capacitances 19 and 20. Therefore, the voltages at two points B and D on the ring resonator 1 is kept zero with respect to the fundamental frequency f0 but the frequency proving the maximum voltage is higher than the secondary harmonic frequency 2f0. Then, providing the grounding capacitors 17 and 18 at the two points B and D on the ring resonator 1 can control the frequency providing the maximum voltage at the two points B and D. In this case, because these points provide zero voltage with respect to the fundamental harmonic frequency f0, so that basic operation is unchanged.

That is, the maximum voltage at the secondary frequency 2f0 is provided by connecting the grounding capacitors 17 and 18, having the same suitable capacitance value, to the two points B and D on the ring resonator 1 and outputs at points B and D have a phase difference of 360°, that is, an in-phase relation, so that the secondary harmonic frequency signal having a larger intensity can be obtained than the first embodiment by the
in-phase combining through the output capacitances 13 and 15. Further, the suppression of the fundamental harmonic component is the same as the first embodiment.

As mentioned above, according to this embodiment, a small-size high frequency band oscillator is provided with a simple circuit structure and a low current consumption because a frequency-up converter which would be connected to an output of the oscillator is unnecessary and a larger output level of the secondary harmonic component is provided by connecting the resonant capacitance 16 between the coupling point A and the point C apart from the coupling point A by the half of the line length of the ring resonator 1 and by connecting the grounding capacitances having the same value to two points B and D on the ring resonator 1 where the voltage is zero with respect to the fundamental frequency f0.

In this embodiment, the output capacitors 13 and 15 are used as the in-phase combining means. However, other in-phase combining circuits can be used for this embodiment. Further, the positions of the points B and D where the voltages are zero with respect to the fundamental harmonic frequency f0 and maximum with respect to the secondary harmonic frequency can be controlled by addition of the grounding capacitor to the point C on the ring resonator 1. Particularly, if a capacitance value of the grounding capacitor is equivalent to the capacitance value of the oscillation portion 2 viewed from the coupling point A, these two points B and D are at middle points of points A and C on the ring resonator.

(EMBODIMENT 6)

Hereinbelow a sixth embodiment of this invention will be described with reference to drawings.

Fig. 7A is a schematic drawing of an oscillator of a first example of the sixth embodiment of this invention. The basic structure of the first example of the sixth embodiment is similar to the first example of the fifth embodiment shown in Fig. 6A and the difference is in that a variable capacitance 21 is used as the capacitor coupling the coupling point A to the point C which is apart from the coupling point A by the half of the line length of the ring resonator 1.

Fig. 7B is a schematic drawing of an oscillator of a second example of the sixth embodiment of this invention. The basic structure of the second example of the sixth embodiment is similar to the second example of the fifth embodiment shown in Fig. 6B and the difference is in that variable capacitances 22 and 23 having the same voltage-capacitance characteristic are used as the grounding capacitors coupling between the coupling point A and the ground and between the point C and the ground to provide a voltage control structure.

Operations of the oscillator of the first and second examples of the sixth embodiment will be described.

If the variable capacitances are not connected asymmetrically (without balance) to the two points A and C providing maximum voltages with respect to the fundamental frequency f0 and when the oscillation frequency is varied with a frequency control voltage inputted through a control input 2a, the points providing zero voltage with respect to the fundamental frequency on the ring resonator 1 moves with the variation of the control voltage. Contrary, if the variable capacitances are connected symmetrically (balance) to the two points A and C providing the maximum voltages with respect to the fundamental frequency f0, the points on the ring resonator providing the zero voltage with respect to the fundamental frequency f0 always stay at the points B and D that is, they do not move with the variation of the oscillation frequency with a variation of the control voltage. Other operations are the same as the fifth embodiment.

As mentioned, according to this embodiment, a small-size high frequency band voltage controlled oscillator having the same characteristic as the oscillators of the first to fifth embodiments can be provided even if the voltage controlling of the oscillation frequency is effected by that the variable capacitor 21 is connected between the coupling point A and the point C or by that the variable capacitors having the same voltage-capacitance characteristic is connected between the coupling point A and the ground and between the point C and the ground, and by that grounding capacitors having the same value are connected between point B and the ground and between D and the ground wherein the voltages at the points B and D are zero with respect to the fundamental frequency f0.

In this embodiment, the output capacitors 13 and 15 are used as the in-phase combining means. However, other in-phase combining circuits can be used for this embodiment. Further, the positions of the points B and D where the voltages are zero with respect to the fundamental frequency f0 and maximum with respect to the secondary harmonic frequency can be controlled by adding the grounding capacitor to the point C. Particularly, if the capacitance value of the grounding capacitor is equivalent to the capacitance value of the oscillation portion 2 viewed from the coupling point A, these two points B and D are at middle points of points A and C on the ring resonator 1.

(EMBODIMENT 7)

Hereinbelow a seventh embodiment of this invention will be described with reference to drawings.

Fig. 8 is a schematic drawing of a frequency synthesizer of the seventh embodiment of this invention. The frequency synthesizer of the seventh embodiment comprises a phase synchronizing circuit 12 for receiving an oscillation output having the fundamental frequency f0 and generating a frequency control signal with reference to a reference signal, the oscillation circuit 2 for generating the oscillation output having the fundamental frequency f0, and the ring resonator 1, coupled with the oscillation circuit 2 at the coupling point A, for outputting
a secondary harmonic component (210) as a resonant signal. At the point B which apart from the coupling point A by a line length less than a quarter of the line length of the ring resonator 1.

An operation of the frequency synthesizer of the seventh embodiment will be described. At first, the oscillation circuit 2 oscillates at a frequency determined by the electrical length of the ring resonator 1 and the circuit constant of the oscillation portion 2. The phase synchronizing circuit 12 receives the fundamental frequency f0 from the oscillation circuit 2 and generates the frequency control signal with reference to the reference signal from the reference signal generator 11. The loop filter circuit 10 removes a high frequency component from the frequency control signal. The oscillation circuit 2 oscillates in accordance with the frequency control signal and thus, oscillates in phase with the reference signal. The oscillation circuit 2 supplies the fundamental frequency component to the coupling point A of the ring resonator 1 through the coupling capacitor 3. The ring resonator 1 resonates in response to the fundamental component and generates and outputs the secondary harmonic frequency component (210) at the point B which is outputted by the output terminal 7 through the output capacitor 13. That is, the point A on the ring resonator 1 shows a maximum voltage with respect to the fundamental frequency f0 and the point B shows a zero voltage with respect to the fundamental frequency f0 and a maximum voltage with respect to the secondary harmonic frequency 2f0. Therefore, the output is obtained from the point B through the output capacitor 13, so that the secondary harmonic frequency component can be obtained with the fundamental component suppressed. In other words, even order harmonic components are obtained and the fundamental component and odd order harmonic components are suppressed. As mentioned, in the frequency synthesizer, the synchronized frequency signal is produced at a low frequency band, on the other hand, the output synchronized frequency signal from the output terminal is obtained at the higher frequency band, so that a low power consumption of the high frequency band frequency synthesizer can be realized.

As mentioned above, according to this embodiment, a superior high frequency band frequency synthesizer having a small circuit scale and a small power consumption can be provided because the frequency-up converter is unnecessary by forming the phase synchronizing circuit through the fundamental component outputted by the oscillator and obtaining the secondary harmonic component from the ring resonator side as shown in Fig. 8.

In this embodiment, the oscillator including the oscillation circuit 2, the resonator 1, and the output terminal obtaining the secondary harmonic frequency component from the point B is the same as the first embodiment. However, the oscillators of the second to sixth embodiments can be used for the frequency synthesizer also in place of the oscillator shown in Fig. 1.

(EMBODIMENT 8)

Hereinbelow an eighth embodiment of this invention will be described with reference to drawings. Fig. 9 is a schematic drawing of an oscillator of the eighth embodiment of this invention.

In Fig. 9, the basic structure of the eighth embodiment is similar to the first embodiment and the difference between the eighth embodiment and the first embodiment is in that instead of the output terminal 7, output terminals 26 and 27 are provided. The output terminals 26 and 27 are coupled to points E and F on the ring resonator 1 through output capacitances 24 and 25. The points E and F have the same line length from the coupling point A and are apart from each other by electrical length 90° at the fundamental frequency f0.

An operation of the oscillator of the eighth embodiment will be described.

At first, the oscillation circuit 2 oscillates at the frequency f0 determined by the electrical length of the ring resonator 1 and the circuit constant of the oscillation circuit 2. Fig. 10 is a graphic diagram of the eighth embodiment showing an output level change with respect to an electrical length from the coupling point A. In Fig. 10, an output level at a position on the ring resonator 1 varies with the electrical length from the coupling point A. There is a point where an output level of the fundamental frequency is substantially zero voltage. However, any other points apart from this point provides the fundamental harmonic component with some output levels. In this case, points E and F are apart from the coupling point A by the same line length, so that outputs having the same level can be obtained at the output terminals 26 and 27. Further, because the points E and F has a phase difference of 90° at the oscillation frequency (fundamental frequency) 10 each other, points E and F output the fundamental components having the phase difference of 90°, that is, they act as isolation ports and thus, do not affect each other.

As mentioned according to this embodiment, as shown in Fig. 9, a superior high frequency band oscillator having a distribution function with a simple circuit structure can be provided by obtaining the oscillator outputs from the two points E and F on the ring resonator 1 apart from the coupling point A by the same line length with the electrical length difference of 90° at the oscillation frequency.

(EMBODIMENT 9)

Hereinbelow a ninth embodiment of this invention will be described with reference to drawings.

Figs. 11A and Fig. 11B are schematic drawings of oscillators of first and second examples of the ninth embodiment of this invention respectively. In Fig. 11A, the difference between the first example of the ninth embod-
iment and eighth embodiment is in that a resonant capacitor 28 is further provided between two points, namely, the coupling point A and the point C apart from the coupling point A by a half of the line length of the ring resonator 1. In Fig. 11B, the difference between the second example of the ninth embodiment and eighth embodiment is that open end transmission lines 29 are provided to the coupling point A and the point C which is apart from the coupling point A by the half of the line length of the ring resonator 1.

Operations of the oscillators of the ninth embodiment will be described.

The basic operations are the same as the eighth embodiment. The difference is in that the line length of the ring resonator 1 can be shortened by providing the resonant capacitor 28 in the first example of the ninth embodiment and the line length of the ring resonator 1 can be shortened by providing the open end transmission lines 29 in the second example of the ninth embodiment.

As mentioned above, according to this embodiment, the ring resonator 1 can be miniaturized by connecting the resonant capacitance 28 or the open end transmission lines 29 as shown in Figs. 11A and 11B, so that a superior small high frequency oscillator having the distribution function with a simple structure can be realized.

Moreover, in Fig. 11B, both open end transmission lines 29 are connected to the two points, namely, the coupling point A and the point which is apart from the coupling point A by a half of the line length of the ring resonator. However, it is also possible that an open end transmission line is connected to only either of the two points.

(EMBODIMENT 10)

Hereinbelow a tenth embodiment of this invention will be described with reference to drawings.

Fig. 12 is a schematic drawing of an oscillator of the tenth embodiment of this invention. In Fig. 12, the difference between the tenth embodiment and the eighth embodiment is in that grounding capacitors 30 and 31 having the same capacitance value are connected to the coupling point A and the point C apart from the coupling point A by the half of the line length of the ring resonator 1.

An operation of the oscillator of this embodiment will be described.

The basic operation is the same as the eighth embodiment. The difference is in that the line length of the ring resonator 1 can be shortened by providing the grounding capacitors 30 and 31.

As mentioned above, according to this embodiment, the ring resonator 1 can be miniaturized by connecting the grounding capacitances 30 and 31 as shown in Fig. 12, so that a superior small high frequency oscillator having the distribution function with a simple structure can be realized.

Moreover, the embodiments in this specification show the ring resonator 1 as the resonator. However, there is no limitation in the shape of the resonator to the ring shape and it can be realised with any shape throughout the specification.

As mentioned above, according to this invention there is provided an oscillator comprising an oscillation portion, having a ring resonator and a negative resistance active circuit coupled to the ring oscillator through a coupling capacitance wherein an output is obtained from a point on the ring resonator where a voltage is zero with respect to the oscillation frequency. Therefore, it is possible to obtain the secondary harmonic component with the fundamental component suppressed, so that a superior high frequency band oscillator having a simple structure and a small power consumption current can be realized.

(EMBODIMENT 11)

Hereinbelow will be described an eleventh embodiment of this invention with reference to drawings.

Fig. 13 is a schematic drawing of an oscillator of the eleventh embodiment of this invention.

In Fig. 13, the oscillator of the eleventh embodiment comprises a first oscillation portion 16 having a ring resonator 1 having points A to D equidistantly dividing the ring resonator 1 and a first oscillation circuit 2A coupled to the point A, a second oscillation portion 17, having the resonator 1 and a second oscillation circuit 2B coupled to the point B, a switch 18 for supplying a supply power to either of the first or second oscillation circuit 2A or 2B in accordance with a switch control signal, and buffer amplifiers 6C and 6D for amplifying oscillation outputs from points C and D wherein the points C and D are the opposite sides of the ring resonator 1 from the points A and B respectively.

The switch 18 supplies the supply power to either of the first oscillation portion 2A or 2B in accordance with the switch control signal. The first oscillation circuit 2A is coupled to the point A on the ring resonator 1 through a capacitor 3A. The second oscillation circuit 2B is coupled to the point B on the ring resonator 1 through a capacitor 3B. A grounding capacitor 12, having a capacitance equivalent a capacitance of the oscillation circuit 2A viewed from the point A, couples the point C to the ground wherein the point C is apart from the point A by a half of the line length of the ring resonator 1. A grounding capacitor 13, having a capacitance equivalent a capacitance of the oscillation circuit 2B viewed from the point B, couples the point D to the ground wherein the point D is apart from the point B by a half of the line length of the ring resonator 1. A resonant capacitor 14 is connected between the points A and C and a resonant capacitor 15 is connected between the points B and D. The buffer amplifier 6C is coupled to the point C through a capacitor 5C and the buffer amplifier 6C is coupled to
the point D through a capacitor 5D. A combining circuit 31 combines the outputs of the buffer amplifiers 6C and 6D.

An operation of the oscillator of the eleventh embodiment will be described.

At first, when the oscillation circuit 16 is supplied with the supply power by the switch 18, the oscillator 16 oscillates at a frequency f1 determined by an electrical length of the ring resonator 1, a circuit constant of the oscillation circuit 2A, a capacitance of the grounding capacitor 12, and a capacitance of the resonant capacitor 14 wherein the point A shows a maximum voltage with respect to the fundamental frequency f1 and a sinusoidal voltage distribution along the line of the ring resonator 1 with respect to the fundamental frequency f1. The points B and D apart from the point A by a quarter of the line length of the ring resonator 1 show minimum voltages with respect to the fundamental component of the oscillation frequency f1, that is, they act as isolation ports and the point C apart by a half of the line length from the point A shows a maximum voltage with respect to the fundamental component of the oscillation frequency. Similarly, the oscillator 17 oscillates at an oscillation frequency f2 determined by the electrical length of the ring resonator 1, a circuit constant of the oscillation portion 2B, a capacitance of the grounding capacitor 13, and a capacitance of the resonant capacitor 15 wherein the point B shows a maximum voltage with respect to the fundamental component of the oscillation frequency f2 and a sinusoidal voltage distribution along the line of the ring resonator 1, the points A and C apart from the point B by a quarter of the line length of the ring resonator 1 show minimum voltages with respect to the oscillation frequency, that is, they act as isolation ports, and the point D apart by a half of the line length from the point B shows a maximum voltage. This structure provides two independent oscillation portions 16 and 17 which do not affect each other using one resonator 1 and provides stable oscillation outputs at the output terminal 7 derived from the points C and D through the capacitors 5C and 5D, the buffer amplifiers 6C and 6D, and the combining circuit 31.

It is generally known that in the voltage controlled oscillator, if a frequency sensitivity to a control voltage is made high, a noise characteristic deteriorates. Contrary, dividing a necessary oscillation frequency band into high and low bands and assigning the oscillation portions 16 and 17 to these bands, namely, the assigning of low and high bands can make the frequency sensitivity of each oscillator small, so that the noise characteristic of the oscillator can be improved.

Moreover, in the time-division two way communication system generally used for the digital mobile unit communication system, transmitting and receiving are effected using the radio wave frequencies having the same frequency at the antenna terminal. Therefore, a local oscillator should have a band broader than the radio wave frequency. In that case, the oscillator can be made to have a low noise due to the effect mentioned above, that is, by assigning the oscillation portions 16 and 17 to transmission frequency band and the receiving frequency band.

Moreover, because either of oscillation portions operates at an instance by switching of supplying of the supply power between the oscillation portions 16 and 17 by the switch circuit 18, so that the consumed current does not increase.

As mentioned, according to this embodiment, the oscillation circuit 2A is connected to the point A through the coupling capacitor 3A, the oscillation circuit 2B is connected to the point B through the coupling capacitor 3B, the grounding capacitor 12 having the capacitance equivalent to that of the oscillation circuit 2A viewed from the point A is connected to the point C, and the grounding capacitor 13 having the capacitance equivalent to that of the oscillation circuit 2B viewed from the point B is connected to the point D wherein respective points equidistantly divides the line length of the ring resonator into four. Therefore, two independent high frequency band oscillation portions 16 and 17 which do not affect each other can be provided with one resonator 1 and the miniaturization of the resonator 1 can be provided by adding resonant capacitors 14 and 15 between the points A and C and between B and D.

Moreover, the noise characteristic can be improved by making the frequency sensitivity required for one oscillator small, so that a small and low noise high frequency band oscillator can be provided.

Further, in the structure shown in Fig. 13, both the resonant capacitors 14 and 15 are added between the points A and C and between points B and D. However, it is possible that only either of resonant capacitor is added.

(EMBODIMENT 12)

Hereinbelow a twelfth embodiment will be described with reference to drawings.

Fig. 14 is a schematic drawing showing a main portion of an oscillator of the twelfth embodiment. In Fig. 14, the difference between the twelfth embodiment and the eleventh embodiment is in that grounding capacitors 19A and 19C having the same capacitance couple the points A and C to the ground and grounding capacitors 20B and 20D having the same capacitance couple the points B and D to the ground respectively. Other structure is similar to the eleventh embodiment. That is, the output capacitors 5C and 5D, the buffer amplifier 6C and 6D, the combining circuit 31, the output terminal 7, and switch circuit 18 are actually provided but are omitted to avoid the complication in the drawing.

An operation of the oscillator of the twelfth embodiment will be described.

The basic operation is the same as that of the eleventh embodiment and the difference is in that the oscillation portion 16 oscillates at the frequency f1 determined
by the electrical length of the ring resonator 1, the circuit constant of the oscillation circuit 2A, and grounding capacitors 12, 19A, and 19C and the oscillation portion 17 oscillates at the frequency f2 determined by the electrical length of the ring resonator 1, the circuit constant of the oscillation circuit 2B, and grounding capacitors 13, 20B, and 20D.

Fig. 15 shows a isolation characteristic between isolation ports and a isolation characteristic between a port and the ground of the eleventh embodiment with respect to a degree of shortening the resonator length. In the eleventh embodiment, if the length of the resonator is shortened to two thirds thereof, there is a little decrease in the isolation degree. However, the isolation degree begins to decrease if the length of the resonator is shortened more. Contrary, the oscillator of the twelfth embodiment maintains a good characteristic of isolation degree between the isolation ports irrespective of the degree of shortening the resonator length as shown.

As mentioned above, according to this invention, as shown in Fig. 14, the oscillation circuit 2A is connected to the point A through the coupling capacitor 3A, the oscillation circuit 2B is connected to the point B through the coupling capacitor 3B, the grounding capacitor 12 equivalent to the capacitance of the oscillation portion 2A viewed from the point A is connected to the point C, and the grounding capacitor 13 equivalent to the capacitance of the oscillation portion 2B viewed from the point B is connected to the point D wherein respective points equidistantly divides the line length of the ring resonator into four. Therefore, two independent high frequency band oscillators which do not affect each other can be provided with one common resonator 1 and the miniaturization of the resonator can be provided in a larger degree by adding grounding capacitors 19A, 19C, 20B and 20D.

In the structure shown in Fig. 14, all points A to D are connected to the grounding capacitors. However, it is also possible that either of a pair of points A and C or a pair of points B and D is provided with grounding capacitors. Moreover, the structure has the grounding capacitors connected to the point C or D in parallel. However, it is also possible that these capacitors are combined into single capacitors respectively.

(EMBODIMENT 13)

Hereinbelow a thirteenth embodiment will be described with reference to drawings.

Fig. 16 is a schematic drawing showing a main portion of an oscillator of the thirteenth embodiment. In Fig. 16, the difference between thirteenth embodiment and the twelfth embodiment is in that grounding capacitors 19A, 19C, 20B and 20D are replaced by open-end transmission lines 21 to 24 and other structure similar to eleventh embodiment. That is, the output capacitors 5C and 5D, the buffer amplifiers 6C and 6D, the combining circuit 31, the output terminal 7, the grounding capacitors 12 and 13, and switch circuit 18 are omitted in Fig. 16.

An operation of the oscillator having the structure mentioned above will be described.

The basic operation is the same as that of the twelfth embodiment and the difference is in that the oscillation portion 16 oscillates at the frequency f1 determined by the electrical length of the ring resonator 1, the circuit constant of the oscillation circuit 2A, and electrical lengths of the open-end transmission lines 21 and 22 and grounding capacitors 12 and the oscillation portion 17 oscillates at the frequency f2 determined by the electrical length of the ring resonator 1, the circuit constant of the oscillation circuit 2B, and electrical lengths of the open-end transmission lines 23 and 24 and grounding capacitors 13. As similar to the twelfth embodiment, the electrical length of the ring resonator 1 can be shortened. Further, due to the distributed constant capacitances, it is possible that the resonator is made flat.

As mentioned above, according to this embodiment, as shown in Fig. 16, the oscillation circuit 2A is connected to the point A through the coupling capacitor 3A, the oscillation circuit 2B is connected to the point B through the coupling capacitor 3B, and the open-end transmission lines are added to points A to D, wherein respective points equidistantly divides the line length of the ring resonator into four. Therefore, the miniaturization of the resonator can be provided. Moreover, the noise characteristic can be improved by making the frequency sensitivity necessary for one oscillator small. Therefore, a small size and low noise high frequency band oscillator can be realized.

Moreover, in the structure shown in Fig. 16, all lump constant capacitances are replaced by the open-end transmission lines. However, it is also possible that a portion of them are replaced.

(EMBODIMENT 14)

Hereinbelow a fourteenth embodiment will be described with reference to drawings.

Fig. 17 is a schematic drawing showing a main portion of an oscillator of the fourteenth embodiment. In Fig. 17, the difference between fourteenth embodiment and the twelfth embodiment is in that variable grounding capacitors 25A and 25C having the same characteristic are added to the points A and C on the ring resonator 1 and variable grounding capacitors 26B and 26D having the same characteristic are added to the points B and D for the voltage controlling. Other structures are similar to the eleventh embodiment. That is, the output capacitors 5C and 5D, the buffer amplifiers 6C and 6D, the combining circuit 31, the output terminal 7, and switch circuit 18 are omitted.

An operation of the oscillator of the fourteenth embodiment will be described.

In the oscillation portion 16, if capacitances of the variable capacitors added to the points A and C where the voltages are maximum with respect to the oscillation
frequency are not equal to each other, with a variation of the oscillation frequency by the control voltage via the control input 2a the point on the ring resonator 1 showing the minimum voltage with respect to the oscillation frequency would move along the resonator 1. Contrary, when the variable capacitors 25A and 25c which are equivalent to each other are added to the points A and C, with the variation of the oscillation frequency does not move the points on the ring resonator 1 showing the minimum voltage with respect to the oscillation frequency.

Similarly, in the oscillation portion 17, when the variable capacitors 26B and 26D which are equivalent to each other are added to the points B and D showing the maximum voltage with respect to the oscillation frequency as shown in Fig. 17, the variation of the oscillation frequency by the control voltage via the control input 2a does not move the points on the ring resonator 1 showing the minimum voltage with respect to the oscillation frequency. Other operations are similar to the twelfth embodiment.

As mentioned above, according to this embodiment, as shown in Fig. 17, the oscillation circuit 2A is connected to the point A through the coupling capacitor 3A, the oscillation circuit 2B is connected to the point B through the coupling capacitor 3B, the grounding capacitor 12 having a capacitance equivalent to that of the oscillation circuit 2A viewed from the point A is connected to the point C, and the grounding capacitor 13 having a capacitance equivalent to that of the oscillation circuit 2B viewed from the point B is connected to the point D wherein respective points equidistantly divides the line length of the ring resonator 1 into four, the variable capacitors 25A and 25C having the same voltage-capacitance characteristic are connected between point A and the ground and between the point C and the ground, and the variable capacitors 26B and 26D having the same voltage-capacitance characteristic are connected between point B and the ground and between the point D and the ground. Therefore, if the oscillation frequency is controlled by the voltage of the frequency control signal, a superior high frequency voltage controlled oscillation having a small size, a superior noise characteristic, and the characteristic equivalent to the oscillator described in the eleventh to thirteenth embodiments is provided.

(EMBODIMENT 15)

Hereinbelow a fifteenth embodiment will be described with reference to drawings.

Fig. 18 is a schematic drawing of an oscillator of the fifteenth embodiment. In Fig. 18, the difference between fifteenth and eleventh embodiments is in that the oscillation portions 16 and 17 oscillate at the same time and outputs are obtained at separate output terminals 27 and 28 through output capacitors 5C and 5D and the buffer amplifiers 6C and 6D.

An operation of the oscillator of the fifteenth embodiment will be described.

The basic operation is similar to the eleventh embodiment. The oscillator 16 oscillating at the frequency f1 shows a maximum voltage at the point A and shows a sinusoidal voltage distribution along the line of the ring resonator 1 wherein the points B and D which are apart from the point A by a quarter of the line length of the ring resonator 1 show minimum voltage and the point C which is apart from the point A by a half of the line length of the ring resonator 1 shows a maximum voltage with respect to the oscillation frequency f1. On the other hand, the oscillation portion 17 oscillating at the frequency f2 shows a maximum voltage at the point B and shows a sinusoidal voltage distribution along the line of the ring resonator 1 wherein the points A and C which are apart from the point B by a quarter of the line length of the ring resonator 1 show minimum voltages and the point D apart from a half of the line length of the ring resonator 1 shows a maximum voltage with respect to the oscillation frequency f2.

If a relation that the isolation degree between points A and B is larger than the injection-locked gain is true between oscillation frequencies of two oscillation portions, both act as independent oscillators which do not affect each other though both oscillation portions 16 and 17 oscillate at the same time. Therefore, though both oscillators operate at the same time, the oscillation output of the oscillator 16 is provided at the output terminal 27 and the oscillation output of the oscillation portion 17 is attenuated by the amount corresponding to the isolation between the points B and C. Similarly, the oscillation output of the oscillation portion 17 is provided at the output terminal 28 and the oscillation output of the oscillation portion 16 is attenuated by the amount corresponding to the isolation between the points A and D.

Generally, in the mobile unit communication, the method of receiving and decoding through twice frequency converting is frequently used. Therefore, since two local oscillator are necessary, if this circuit structure is applied to it, the whole structure of the local oscillator can be simplified. Fig. 22 is a block diagram of an example circuit using the oscillator of the fifteenth embodiment. In Fig. 22, a radio wave signal is received by a receiving circuit 101. A received radio signal is frequency converted by a first frequency converter 102 using the oscillation signal having the oscillation frequency f1. An output of the frequency converter 102 is frequency converted by a second frequency converter 103 using the oscillation signal having the oscillation frequency f2 again. Then, an output of the second frequency converter 103 is detected by a detector 104.

As mentioned above, according to this embodiment, as shown in Fig. 18, the oscillation circuit 2A is connected to the point A through the coupling capacitor 3A, the oscillation circuit 2B is connected to the point B through the coupling capacitor 3B, the grounding capacitor 12C equivalent to the capacitance of the oscillation
circuit 2A viewed from the point A is connected to the point C, and the grounding capacitor 13 equivalent to the capacitance of the oscillation circuit 2B viewed from the point B is connected to the point D wherein respective points equidistantly divide the line length of the ring resonator into four and the oscillation frequencies of two oscillators are suitably set, so that though two oscillators oscillates at the same time, two independent high frequency band oscillators which do not affect each other are provided with one common resonator 1 even if two oscillators oscillates at the same time. Therefore, the circuit structure of the whole of the local oscillator can be simplified.

Fig. 18 shows the oscillation circuits 2A and 2B according to the structure of the eleventh embodiment. However, the oscillation circuits 2A and 2B of twelfth to fourteenth embodiments can be used for this embodiment.

(Embodiment 16)

Hereinbelow a sixteenth embodiment of this invention will be described with reference to drawings.

Fig. 19 is a schematic drawing of a frequency synthesizer of the sixteenth embodiment. The frequency synthesizer 105 of the sixteenth embodiment comprises a first oscillation portion 16 for generating a first oscillation frequency signal and resonating the ring resonator 1 (not shown in Fig. 19), a second oscillation portion 17 for generating a second oscillation frequency signal and resonating the ring resonator 1, a switch 18 for switching of supplying a supply power to either of the first or the second oscillation portion 16 or 17, a reference signal generator 11 for generating a reference signal, a phase synchronizing circuit 9 for generating a frequency control signal by comparing the first or the second oscillation frequency signal with the reference signal and supplying the frequency control signal to the oscillation portions 16 and 17 through the loop filter 10, a buffer amplifier 6C for receiving an oscillation frequency signal from the oscillation portion 16 through a coupling capacitor 5C, a buffer amplifier 6D receiving an oscillation frequency signal from the oscillation portion 17 through a coupling capacitor 5D, and a combining circuit 31 for combining the output of the buffer amplifiers 6C and 6D, wherein the first and second oscillation portions 16 and 17 have the same frequency sensitivity.

An operation of the frequency synthesizer 105 of the sixteenth embodiment will be described.

As described in the eleventh embodiment, in the time-division two way communication system used for the digital mobile unit communication system, the output frequency of the frequency synthesizer 105 is switched between transmission and receiving frequencies every time slot of transmission and receiving. Then, if the oscillation portions 16 and 17 cover frequency bands of transmission and receiving respectively and the frequency sensitivities to the control voltage are set to the same value, the control voltages are the same between the transmission and receiving operations.

Therefore, a transition response time of the phase synchronizing circuit due to a variation of the control voltage occurring on switching the frequency between the transmission and receiving operations can be reduced and a high speed frequency-lock can be realized. Moreover, the external output is obtained from the ring resonator side and the input signal to the phase synchronizing circuit 9 is obtained from the oscillator side, so that the distributor which was generally connected to the oscillator output can be omitted.

As mentioned above, according to this embodiment, as shown in Fig. 19, the oscillation portions 16 and 17 have the same frequency sensitivities to the control voltage, so that the transition response time on switching the frequency can be reduced. Therefore, a superior high frequency band frequency synthesizer 105 showing a short frequency-lock interval with a simple structure.

Fig. 23 is a block diagram of an example of a circuit using the frequency synthesizer 105 of the sixteenth embodiment. A radio wave signal is received by a receiver 106 using the oscillation signal having a frequency fl from the frequency synthesizer 105 and outputs a received radio signal. In this condition, the frequency synthesizer is supplied with the switch control signal indicating that the supply power is supplied to the oscillation portion 16. Therefore, only the oscillation portion 16 oscillates and supplies the oscillation signal to the receiver 106 in this condition. In the transmission condition, the frequency synthesizer is supplied with the switch control signal indicating that the supply power is supplied to the oscillation portion 17. Therefore, only the oscillation portion 17 oscillates and supplies the oscillation signal to the transmitter 107 which transmits a radio signal.

As mentioned, according to this invention, a first oscillation circuit having a negative resistance active circuit is connected to a first point on the ring resonator through a first coupling capacitance, wherein respective points equidistantly divides the line length of the ring resonator into four, a second oscillation circuit having a negative resistance active circuit is connected to the second point on the ring resonator, which is apart from the first point by a quarter of the line length, through a second coupling capacitor, a grounding capacitor having a capacitance equal to that of the first oscillation circuit viewed from the first point is connected to a third point apart from the first point by a half of line length, and a grounding capacitor having capacitances equivalent to the capacitance of the second oscillation circuit viewed from the second point is connected to a fourth point apart from the second point by a half of the line length. Therefore, two independent high frequency band oscillators which do not affect each other can be realised. Moreover, at least a resonant capacitance is add between first and third points or between second
and fourth points at least or at least a grounding capacitor is add between first and third or between second and fourth, so that the resonator can be miniaturized and two small independent high frequency band oscillators which do not affect each other can be realized with one resonator and a frequency synthesizer showing a high speed locking using the oscillator can be realized with a simple structure.

Claims

1. An oscillator comprising:
   a ring resonator (1), and
   an oscillation circuit (2) having a negative resistance active circuit coupled to a first point (A) on said ring resonator for oscillating at a fundamental oscillation frequency and resonating said resonator characterized by:
   an output terminal, coupled to a second point (B) on said ring resonator where a voltage is substantially zero with respect to said fundamental oscillation frequency when said ring resonator resonates, for outputting a second harmonic frequency signal.

2. An oscillator according to claim 1, wherein said output terminal is coupled to a third point (D1) where a voltage is substantially zero with respect to said oscillation frequency when said ring resonator resonates, and said second point by an in-phase combining circuit (13, 15).

3. An oscillator according to claim 1 or 2, further comprising:
   a first grounding capacitor (14, 20, 31) for coupling a fourth point (C) on said ring resonator to ground, said fourth point being apart from said first point (A) by a half of the line length of said ring resonator.

4. An oscillator according to claim 3, wherein said grounding capacitor (14) has a capacitance equivalent to the capacitance of said oscillation circuit viewed from said first point (A).

5. An oscillator according to claim 2 or 3, further comprising:
   a second grounding capacitor (17) connected between said second point (B) and ground; and
   a third grounding capacitor (18) connected between said third point (D) and ground, said first ground capacitor (17) having a capacitance which is substantially equal to a capacitance of said second ground capacitor (18).

6. An oscillator according to claim 5, further comprising:
   a variable capacitor (21), having a variable capacitance, connected between said first point (A) and a fourth point (C) which is apart from said first point by a half of a line length of said ring resonator.

7. An oscillator according to claim 5, further comprising:
   a first variable capacitor (22) connected between said first point (A) and the ground; and
   a second variable capacitor (23) connected between a fourth point (L) and the ground, said fourth point (C) being apart from said first point (A) by a half of a line length of said ring resonator, said first and second variable capacitor having substantially the same voltage-capacitance characteristic.

8. An oscillator according to claim 1, or claim 3 when dependent on claim 1, further comprising:
   a second output terminal, coupled to a third point which is apart from said first point by the same line length as said second point along said ring resonator and is apart from said second point by an electrical length of 90° with respect to said fundamental oscillation frequency along said ring resonator.

9. An oscillator according to claim 5 or 8, further comprising:
   a resonant capacitor (16, 28) connected between said first point (A) and a fourth point (C), which is apart from said first point by a half of a line length of said ring resonator.

10. An oscillator according to any one of claims 3, or any of the preceding claims dependent on claim 3, further comprising:
    a fourth grounding capacitor (19, 30) connected between said first point (A) and the ground, said first and fourth grounding capacitors having substantially the same capacitance.

11. An oscillator according to claim 8, further comprising at least an open-end transmission line (29) connected to at least one of said first point (A) and a fourth point (C).

12. An oscillator according to any one of the preceding claims, wherein said oscillation circuit has a control input for receiving a control signal (2a) and oscillates at said oscillation frequency controlled in accordance with said control signal.

13. A frequency synthesizer comprising:
an oscillator according to claim 12, and
a phase synchronizing circuit for generating
said control signal by comparing a reference
signal with said oscillation signal.

14. An oscillator according to claim 1, further comprising:

a second oscillation circuit having a second
negative resistance active circuit (2B) coupled
to a second point (B) on said ring resonator (1)
which is apart from said first point (4) by a quar-
ter of the line length of said ring member for os-
cillating at a second oscillation frequency which
is different from said first oscillation frequency
and for resonating said resonator;
a first grounding capacitor (12) for coupling a
third point (C) on said ring resonator (1) to the
ground, said third point (C) being apart from
said first point (A) by a half of said predeter-
mined line length, said first grounding capacitor
(12) having a first capacitance (C) equivalent
to a capacitance of said first oscillation circuit
viewed from said first point;
a second grounding capacitor (13) for coupling a
fourth point (D) on said ring resonator (1) to the
ground, said fourth point (D) being apart from
said second point (B) by a half of said predeter-
mined line length, said second grounding capacitor
(13) having a second capacitance (C) equivalent
to a capacitance of said second oscillation circuit
viewed from said second point;
and
an outputting circuit (5C, 6C, 5D, 6D, 31) for
supplying first and second outputs from said
third and fourth points (C, D) respectively.

15. An oscillator as claimed in claim 13, further comprising a switch (18) for switching a supply power
to either of said first or second oscillation circuit (2A, 2B) in accordance with a control signal.

16. An oscillator as claimed in claim 14 or 15, wherein
said outputting circuit comprises first and second
buffer amplifiers (6C, 6D) for amplifying outputs
from said third and fourth points (C, D) respectively
and a combining circuit (31) for combining outputs
of said first and a second buffer amplifiers.

17. An oscillator as claimed in claim 14, 15 or 16, further
comprising at least one resonant capacitance (14, 15)
provided to at least one of a first pair of said first
and third points and a second pair of said second
and fourth points.

18. An oscillator as claimed in claim 14, 15, 16 or 17,
further comprising at least one pair of grounding ca-
cpacitors (19A, 19B, 20B, 20D) having substantially
the same capacitance, for coupling to the ground,
said at least a pair of grounding capacitors being
provided to at least one of a first pair of said first
and third points and a second pair of said second
and fourth points respectively.

19. An oscillator as claimed in claim 18, wherein said
at least a pair of grounding capacitors comprise
transmission lines respectively.

20. An oscillator according to any one of claims 14 to
16, further comprising at least one pair of variable
capacitors (25A, 25C; 26B, 26D) provided to at least
one of a first pair of said first and third points and a
second pair of said second and fourth points re-
spectively, for coupling to the ground.

21. An oscillator according to claim 20, wherein said
pair of variable capacitors have substantially the
same voltage-capacitance characteristic.

22. An oscillator as claimed in any one of claims 14 to
21, wherein said first and second grounding capac-
itors comprise transmission lines respectively.

23. An oscillator as claimed in any one of claims 14 to
22, wherein said first oscillation frequency is higher
than said second oscillation frequency.

24. A communication apparatus for transmitting a first
radio signal and receiving a second radio signal,
comprising:
an oscillator according to claim 15, or any one
of claims 16 to 23 when dependent on claim 15;
transmission means (107) for transmitting said
first radio signal using said first output as a car-
rier signal and supplying said control signal to
said switch to supply said supply power to said
first oscillation circuit; and
receiving means (106) for receiving said sec-
don radio signal using said second output to de-
tect said second radio signal and supplying said
control signal to said switch to supply said sup-
ply power to said second oscillation circuit.

25. A communication apparatus for receiving a radio
signal, comprising:
an oscillator according to any one of claims 14
to 23, receiving means (101) for receiving said
radio signal;
a first frequency (102) converting circuit for
converting said radio signal from said receiving
means using said first output;
a second frequency converting (103) circuit for
converting an output of said first frequency con-
verting circuit using said second output; and
a detector (104) for detecting said radio signal using an output of said second frequency converting circuit.

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Patentansprüche

1. Oszillator, mit:
   einem Ringresonator (1); und mit einer Schwingungsschaltung (2) mit einer aktiven Schaltung mit negativem Widerstand, die mit einem ersten Punkt (A) des Ringresonators verbunden ist, um auf einer Grundschwingungsfrequenz zu schwingen und den Resonator in Resonanz treten zu lassen; gekennzeichnet durch:
   einen Ausgangsanschluß, der mit einem zweiten Punkt (B) auf dem Ringresonator verbunden ist, wobei eine Spannung in Hinsicht auf die Grundschwingfrequenz im wesentlichen Null ist, wenn der Ringresonator schwingt, um ein Frequenzsignal der zweiten Harmonischen abzugeben.

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2. Oszillator nach Anspruch 1, dessen Ausgangsanschluß einerseits mit einem dritten Punkt (D1) gekoppelt ist, an dem eine Spannung in Bezug auf die Schwingfrequenz im wesentlichen Null ist, wenn der Ringresonator schwingt, und andererseits über eine mitphasige Zusammensetzungsschaltung (13, 15) mit dem zweiten Punkt.

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3. Oszillator nach Anspruch 1 oder 2, der des weiteren ausgestattet ist mit:
   einem ersten Massekondensator (14, 20, 31), der einen vierten Punkt (C) auf dem Ringresonator mit Masse verbindet, wobei der vierte Punkt um die halbe Länge des Ringresonators vom ersten Punkt (A) entfernt liegt.

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4. Oszillator nach Anspruch 3, dessen Massekondensator (14) eine Kapazität hat, die der vom ersten Punkt (A) aus gesehenen Kapazität der Oszillatorschaltung äquivalent ist.

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5. Oszillator nach Anspruch 2 oder 3, der des weiteren ausgestattet ist mit:
   einem zweiten Massekondensator (17), der zwischen den zweiten Punkt (B) und Masse geschaltet ist; und mit einem dritten Massekondensator (18), der zwischen den dritten Punkt (D) und Masse geschaltet ist, wobei der erste Massekondensator (17) eine Kapazität hat, die im wesentlichen gleich einer Kapazität des zweiten Massekondensators (18) ist.

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6. Oszillator nach Anspruch 5, der des weiteren ausgestattet ist mit:
   einem variablen Kondensator (21) mit einer variablen Kapazität, der zwischen den ersten Punkt (A) und einen vierten Punkt (C) geschaltet ist, der vom ersten Punkt um die Hälfte einer Leitungslänge des Ringresonators entfernt angeordnet ist.

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7. Oszillator nach Anspruch 5, der des weiteren ausgestattet ist mit:
   einem ersten variablen Kondensator (22), der zwischen den ersten Punkt (A) und Masse geschaltet ist; und mit einem zweiten variablen Kondensator (23), der zwischen einen vierten Punkt (L) und Masse geschaltet ist, wobei der vierte Punkt (C) vom ersten Punkt (A) um die Hälfte einer Leitungslänge des Ringresonators entfernt ist, wobei der erste und zweite variable Kondensator in wesentlichen dieselben Spannungs-Kapazitäts-Kennlinien haben.

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8. Oszillator nach Anspruch 1 oder 3, sofern dieser auf Anspruch 1 rückbezogen ist, der des weiteren ausgestattet ist mit:
   einem zweiten Ausgangsanschluß, der mit einem dritten Punkt verbunden ist, der vom ersten Punkt um dieselbe Leitungslänge entfernt ist wie der zweite Punkt entlang dem Ringresonator und vom zweiten Punkt um die elektrische Länge von 90° in Hinsicht auf die Grundschwingfrequenz entlang des Ringresonators entfernt ist.

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9. Oszillator nach Anspruch 5 oder 8, der des weiteren ausgestattet ist mit:
   einem Resonanzkondensator (16, 28), die zwischen den ersten Punkt (A) und einen vierten Punkt (10) geschaltet ist, der vom ersten Punkt um die Hälfte einer Leitungslänge des Ringresonators entfernt ist.

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10. Oszillator nach Anspruch 3 oder nach einem der vorstehenden, auf Anspruch 3 rückbezogenen Ansprüche, der des weiteren ausgestattet ist mit:
    einem vierten Massekondensator (19, 30), der zwischen den ersten Punkt (A) und Masse geschaltet ist, wobei der erste und vierte Kondensator im wesentlichen von gleicher Kapazität sind.

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11. Oszillator nach Anspruch 8, der des weiteren über wenigstens eine Leerlauf-Übertragungsleistung (29) verfügt, die mit wenigstens entweder dem ersten Punkt (A) oder dem vierten Punkt (C) verbunden ist.

12. Oszillator nach einem der vorstehenden Ansprüche, dessen Oszillatorschaltung einen Steuereingang hat, der ein Steuersignal (2a) empfängt und
mit der gemäß dem Steuersignal gesteuerten Schwingungsfrequenz schwingt.

13. Frequenzsynthesizer, mit:

einem Oszillator nach Anspruch 12, und mit einer Phasensynchronisierungsschaltung, die das Steuersignal durch Vergleich eines Bezugs- signals mit dem Schwingungssignal erzeugt.

14. Oszillator nach Anspruch 1, der des weiteren ausgestattet ist mit:

einer zweiten Oszillatorschaltung mit einer aktiven Schaltung (2B) mit einem negativen Widerstand, die mit dem zweiten Punkt (B) des Ringresonators (1) verbunden ist, der vom ersten Punkt (A) um ein Viertel der Leitungslänge des Rigglegdes entfernt ist, um auf einer zweiten Schwingungsfrequenz zu schwingen, die sich von der ersten Schwingungsfrequenz unterscheidet, und um des Resonator in Resonanz treten zu lassen:
einer ersten Massekapazität (12), die einen dritten Punkt (C) auf dem Ringresonator (1) mit Masse verbindet, wobei der dritte Punkt (C) vom ersten Punkt (A) um die Hälfte der vorbestimmten Leitungslänge entfernt ist, wobei der erste Massekondensator (12) mit einer ersten Kapazität (C), die vom ersten Punkt aus gesehen, einer Kapazität der ersten Schwingungs- schaltung äquivalent ist;
einem zweiten Massekondensator (13), der einen vierten Punkt (D) auf dem Ringresonator (1) mit Masse verbindet, wobei der vierte Punkt (D) vom zweiten Punkt (B) um die Hälfte der vorbestimmten Leitungslänge entfernt ist, wobei der zweite Massekondensator (13) mit einer zweiten Kapazität (C), die vom zweiten Punkt aus gesehen einer Kapazität der zweiten Oszillatorschaltung äquivalent ist; und mit einer Ausgangsschaltung (5C, 6C, 5D, 6D, 31) zum Liefern erster und zweiter Ausgangssignale aus dem dritten beziehungsweise vierten Punkt (C, D).

15. Oszillator nach Anspruch 13, der des weiteren einen Schalter (18) enthält, der eine Stromversorgung gemäß einem Steuersignal entweder mit der ersten oder zweiten Oszillatorschaltung (2A, 2B) verbindet.

16. Oszillator nach Anspruch 14 oder 15, dessen Ausgangsbereich ausgestattet ist mit einem ersten und zweiten Pufferverstärker (6C, 6D), um die Ausgangssignale des dritten beziehungsweise vierten Punktes (C, D) zu verstärken, und mit einer Zusammensetzungsschaltung (31) zum Zusammensetzen der Ausgangssignale des ersten und zweiten Pufferverstärkers.

17. Oszillator nach Anspruch 14, 15 oder 16, der des weiteren ausgestattet ist mit wenigstens einer Resonanzkapazität (14, 15), die zumindest entweder für ein erstes Paar des ersten und dritten Punktes oder für ein zweites Paar des zweiten und vierten Punktes vorgesehen ist.


22. Oszillator nach einem der Ansprüche 14 bis 21, dessen erster und zweiter Massekondensator jeweils über eine Übertragungsleitung verfügt.

23. Oszillator nach einem der Ansprüche 14 bis 22, bei dem die erste Schwingungsfrequenz höher ist als die zweite Schwingungsfrequenz.

24. Kommunikationsgerät zum Senden eines ersten Radiosignals und zum Empfangen eines zweiten Radiosignals, mit:
einem Oszillator nach Anspruch 15 oder einem der Ansprüche 16 bis 23, sofern auf Anspruch 15 zurückbezogen;
Sendemitteln (107) zum Senden des ersten Radiosignals unter Verwendung des ersten Ausgangssignals als Trägersignal und zum Liefern des Steuersignals an den Schalter, um die Stromversorgung der ersten Oszillatorschaltung zuzuführen; und mit Empfangsmitteln (106) zum Empfangen des
Zweiten Radiosignals unter Verwendung des zweiten Ausgangssignals zum Feststellen des zweiten Radiosignals und zum Liefern des Steuersignals an den Schalter, um die Stromversorgung mit der zweiten Oszillatorschaltung zu verbinden.

25. Kommunikationsgerät zum Empfang eines Radiosignals, mit: einem Oszillator nach einem der Ansprüche 14 bis 23;
Empfangsmitteln (101), die das Radiosignal empfangen; einer ersten Frequenzumsetzschaltung (102), die das Radiosignal aus den Empfangsmitteln unter Verwendung des ersten Ausgangssignals umsetzt; einer zweiten Frequenzumsetzschaltung (103), die ein Ausgangssignal der ersten Frequenzumsetzschaltung unter Verwendung des zweiten Ausgangssignals umsetzt; und mit einem Detektor (104) zum Feststellen des Radiosignals unter Verwendung eines Ausgangssignals der zweiten Frequenzumsetzschaltung.

Revendications

1. Oszillator comprenant:
un resonator en anneau (1), et un circuit d’oscillation (2) comportant un circuit actif à résistance négative relié à un premier point (A) sur ledit resonator en anneau en vue d’une oscillation à une fréquence d’oscillation fondamentale et mettant en résonance ledit resonator, caractérisé par:
une borne de sortie, reliée à un second point (B) sur ledit resonator en anneau, où une tension est pratiquement nulle par rapport à ladite fréquence d’oscillation fondamentale lorsque ledit resonator en anneau résonne, en vue de fournir en sortie un signal à fréquence de second harmonique.

2. Oszillator selon la revendication 1, dans lequel la dite borne de sortie est reliée en un troisième point (D1) où une tension est pratiquement nulle par rapport à ladite fréquence d’oscillation lorsque ledit resonator en anneau résonne, et audit second point par un circuit de combinaison en phase (13, 15).

3. Oszillator selon la revendication 1 ou 2, comprenant en outre:
un premier condensateur de mise à la masse (14, 20, 31) destiné à relier un quatrième point (C) sur ledit resonator en anneau à la masse, ledit quatrième point étant séparé dudit premier point (A) par une moitié de la longueur de ligne dudit resonator en anneau.

4. Oszillator selon la revendication 3, dans lequel ledit condensateur de mise à la masse (14) présente une capacité équivalente à la capacité dudit circuit d’oscillation vue depuis ledit premier point (A).

5. Oszillator selon la revendication 2 ou 3, comprenant en outre:
un second condensateur de mise à la masse (17) relié entre ledit second point (B) et la masse, et un troisième condensateur de mise à la masse (18) relié entre ledit troisième point (D) et la masse, ledit premier condensateur de mise à la masse (17) présentant une capacité qui est pratiquement égale à une capacité dudit second condensateur de mise à la masse (18).

6. Oszillator selon la revendication 5, comprenant en outre:
un condensateur variable (21), présentant une capacité variable, relié entre ledit premier point (A) et un quatrième point (C) qui est séparé dudit premier point par une moitié de la longueur de ligne dudit resonator en anneau.

7. Oszillator selon la revendication 5, comprenant en outre:
un premier condensateur variable (22) relié entre ledit premier point (A) et la masse, et un second condensateur variable (23) relié entre un quatrième point (L) et la masse, ledit quatrième point (C) étant séparé dudit premier point (A) par une moitié d’une longueur de ligne dudit resonator en anneau, ledits premier et second condensateurs variables présentant pratiquement la même caractéristique tension-capacité.

8. Oszillator selon la revendication 1, ou la revendication 3 lorsqu’elle dépend de la revendication 1, comprenant en outre:
one seconde borne de sortie, reliée à un troisième point qui est séparé dudit premier point par la même longueur de ligne que ledit second point le long dudit resonator en anneau et qui est séparé dudit second point par une longueur électrique de 90° par rapport à ladite fréquence d’oscillation fondamentale le long dudit resonator en anneau.

9. Oszillator selon la revendication 5 ou 8, comprenant en outre:
un condensateur de résonance (16, 28) relié
entre ledit premier point (A) et un quatrième point (C), qui est séparé dudit premier point par une moitié de la longueur de ligne dudit résonateur en anneau.

10. Oscillateur selon la revendication 3, ou l’une quelconque des revendications précédentes lorsqu’elles dépendent de la revendication 3, comprenant en outre:
un quatrième condensateur de mise à la masse (19, 30) relié entre ledit premier point (A) et la masse, ledits premier et quatrième condensateurs de mise à la masse présentant sensiblement la même capacité.

15. Oscillateur selon la revendication 8, comprenant en outre au moins une ligne de transmission à extrémité ouverte (29) reliée à au moins l’un dudit premier point (A) et d’un quatrième point (C).

12. Oscillateur selon l’une quelconque des revendications précédentes, dans lequel ledit circuit d’oscillation comporte une entrée de commande destinée à recevoir un signal de commande (2A) et oscille à ladite fréquence d’oscillation commandée conformément audit signal de commande.

13. Synthétiseur de fréquence comprenant:
un oscillateur selon la revendication 12, et
un circuit de synchronisation de phase destiné à générer ledit signal de commande en comparaissant un signal de référence audit signal d’oscillation.

14. Oscillateur selon la revendication 1, comprenant en outre:
un second circuit d’oscillation comportant un second circuit actif à résistance négative (2B) relié à un second point (B) sur ledit résonateur en anneau (1) qui est séparé dudit premier point (4) par un quart de la longueur de ligne dudit élément en anneau en vue d’une oscillation à une seconde fréquence d’oscillation qui est différente de ladite première fréquence d’oscillation et afin de mettre en résonance ledit résonateur,
un premier condensateur de mise à la masse (12) destiné à relier un troisième point (C) sur ledit résonateur en anneau (1) à la masse, ledit troisième point (C) étant séparé dudit premier point (A) par une moitié de ladite longueur de ligne prédéterminée, ledit premier condensateur de mise à la masse (12) présentant une première capacité (C) équivalente à une capacité dudit premier circuit d’oscillation vue depuis ledit premier point.

15. Oscillateur selon la revendication 13, comprenant en outre un commutateur (18) destiné à commuter une alimentation vers l’un ou l’autre dudit premier ou dudit second circuit d’oscillation (2A, 2B) conformément à un signal de commande.

16. Oscillateur selon la revendication 14 ou 15, dans lequel ledit circuit de sortie comprend des premier et second amplificateurs tampon (6C, 6D) destinés à amplifier les sorties provenant desdits troisième et quatrième points (C, D) respectivement, et un circuit de combinaison (31) destiné à combiner les sorties desdits premier et second amplificateurs tampon.

17. Oscillateur selon la revendication 14, 15 ou 16, comprenant en outre au moins une capacité de résonance (14, 15) disposée au niveau d’au moins l’une d’une première paire desdits premier et troisième points et d’une seconde paire desdits second et quatrième points.

18. Oscillateur selon la revendication 14, 15, 16 ou 17, comprenant en outre au moins une paire de condensateurs de mise à la masse (19A, 19B ; 20B, 20D) présentant sensiblement la même capacité, en vue d’une liaison à la masse, ladite au moins une paire de condensateurs de mise à la masse étant disposée au niveau d’au moins l’une d’une première paire desdits premier et troisième points et d’une seconde paire desdits second et quatrième points, respectivement.

19. Oscillateur selon la revendication 18, dans lequel ladite au moins une paire de condensateurs de mise à la masse comprend respectivement des lignes de transmission.

et d'une seconde paire desdits second et quatrième points, respectivement, en vue d’une liaison à la masse.

21. Oscillateur selon la revendication 34, dans lequel ladite paire de condensateurs variables présentent sensiblement la même caractéristique tension-capacité.

22. Oscillateur selon l’une quelconque des revendications 14 à 21, dans lequel lesdits premier et second condensateurs de mise à la masse comprennent respectivement des lignes de transmission.

23. Oscillateur selon l’une quelconque des revendications 14 à 22, dans lequel ladite première fréquence d’oscillation est plus élevée que ladite seconde fréquence d’oscillation.

24. Dispositif de communications destiné à émettre un premier signal radio et à recevoir un second signal radio, comprenant :

   un oscillateur selon la revendication 15, ou
   l’une quelconque des revendications 16 à 23
   lorsqu’elles dépendent de la revendication 15,
   un moyen d’émission (107) destiné à émettre
   ladit premier signal radio en utilisant ladite
   première sortie en tant que signal de portée et
   en appliquant ladit signal de commande audit
   commutateur afin d’appliquer ladite alimenta-
   tion audit premier circuit d’oscillation, et
   un moyen de réception (106) destiné à recevoir
   ladit second signal radio en utilisant ladite
   seconde sortie afin de détecter ladit second signal
   radio et en appliquant ladit signal de comman-
   de audit commutateur de façon à appliquer la-
   dite alimentation audit second circuit d’oscilla-
   tion.

25. Dispositif de communications destiné à recevoir un signal radio, comprenant :

   un oscillateur selon l’une quelconque des re-
   vendications 14 à 23,
   un moyen de réception (101) destiné à recevoir
   ladit signal radio,
   un premier circuit de conversion de fréquence
   (102) destiné à convertir ladit signal radio pro-
   venant dudit moyen de réception en utilisant la-
   dite première sortie,
   un second circuit de conversion de fréquence
   (103) destiné à convertir une sortie dudit pre-
   mier circuit de conversion de fréquence en uti-
   lisant ladite seconde sortie, et
   un détecteur (104) destiné à détecter ladit si-
   gnal radio en utilisant une sortie dudit second
   circuit de conversion de fréquence,
FIG. 1

RING RESONATOR

COUPLING CAP

OSC CKT

OUTPUT CAP

OUTPUT TERM

2f₀

FIG. 2

VOLTAGE DISTRIBUTION WITH RESPECT TO 2f₀

VOLTAGE DISTRIBUTION WITH RESPECT TO f₀
FIG. 5

FIG. 8
FIG. 9

\[ \theta_5 = 90^\circ \text{ OF ELECTRICAL LENGTH AT } f_0 \]

FIG. 10

OUTPUT LEVEL OF FUNDAMENTAL COMPONENT

ELECTRICAL LENGTH FROM COUPLING POINT A
FIG. 11A

27 OUTPUT TERM

25 OUTPUT CAP

28 RESONANT CAP

24 OUTPUT CAP

26 OUTPUT TERM

θ₅ = 90° OF ELECTRICAL LENGTH AT f₀

FIG. 11B

27 OUTPUT TERM

25 OUTPUT CAP

29 OPEN END XMSN LINE

24 OUTPUT CAP

26 OUTPUT TERM

θ₅ = 90° OF ELECTRICAL LENGTH AT f₀
FIG. 12

27 OUTPUT TERM
25 OUTPUT CAP
31 GROUNDING CAP
24 OUTPUT CAP
26 OUTPUT TERM
1
A
F
E

3
30 GROUNDING CAP

2

OSC CKT

θ₅ = 90° OF ELECTRICAL LENGTH AT f₀
FIG. 14

FIG. 15

ISOLATION DEGREE (dB)

BETWEEN PORTS

BETWEEN PORT AND THE GROUND

ELECTRICAL LENGTH OF RESONATOR (deg)