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(58) Field of Search
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INT CL^6 **H03B 5/12**
ONLINE:WPI

(54) **Voltage controlled oscillator with band switching**

(57) A voltage controlled oscillator for an up/down-converter in a digital radio communication system is described. The oscillator comprises a resonance unit 100 and an oscillating unit 200 which oscillates at a frequency corresponding to the resonance point of the resonance unit 100. The resonance unit includes a first variable capacitance component VD1 having a capacitance dependent upon the level of an applied control voltage VCTR, a second variable capacitance component VD2 having a capacitance dependent upon the level of an applied mode voltage V_{TX}, V_{RX} and an inductive component L. The first and second variable capacitance components VD1, VD2 and the inductive component L are connected to one another with the inductive component L connected in parallel with at least one of the variable capacitance components VD1, VD2. This arrangement is advantageous in that the local oscillating frequency for transmission/reception which is required in each mode can be output by applying the voltage indicative of the transmitting mode or the reception mode, without increasing the range of variations in the oscillating frequency.

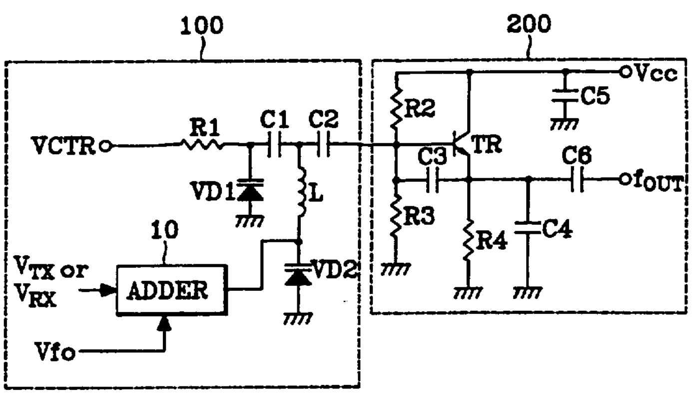

Fig. 4

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

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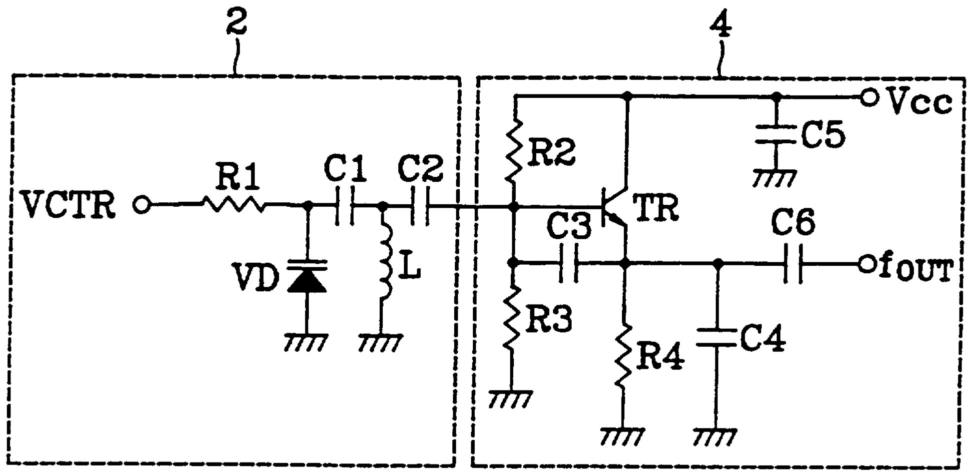

(PRIOR ART)

Fig. 1

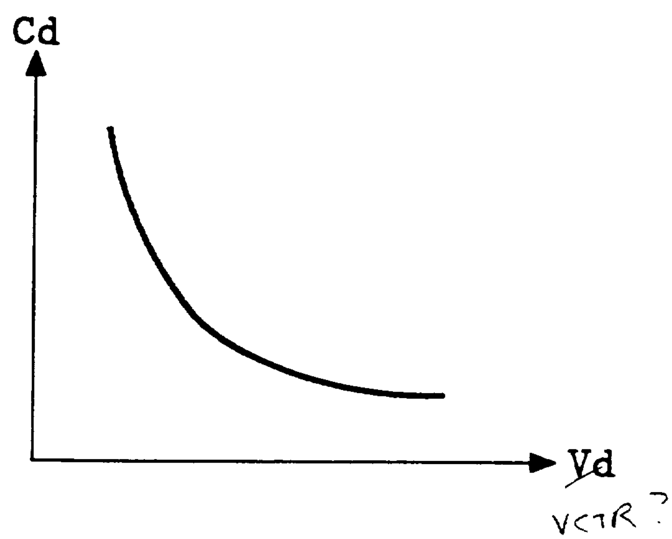

Fig. 2

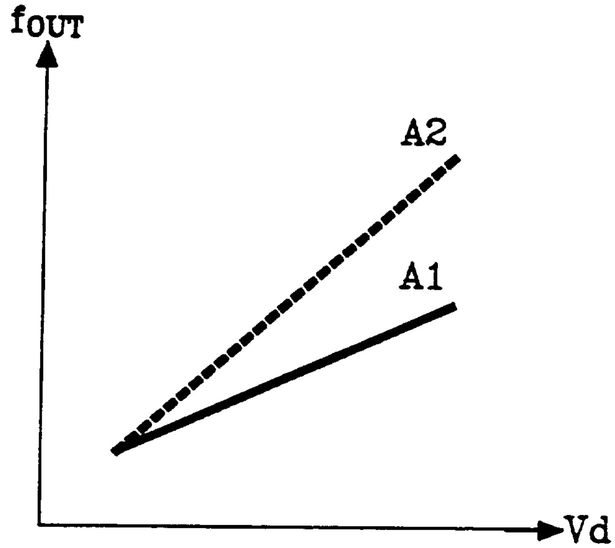

Fig. 3A

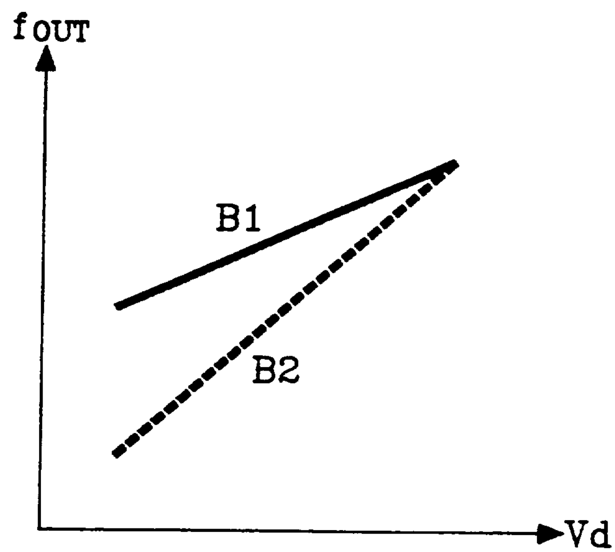

Fig. 3B

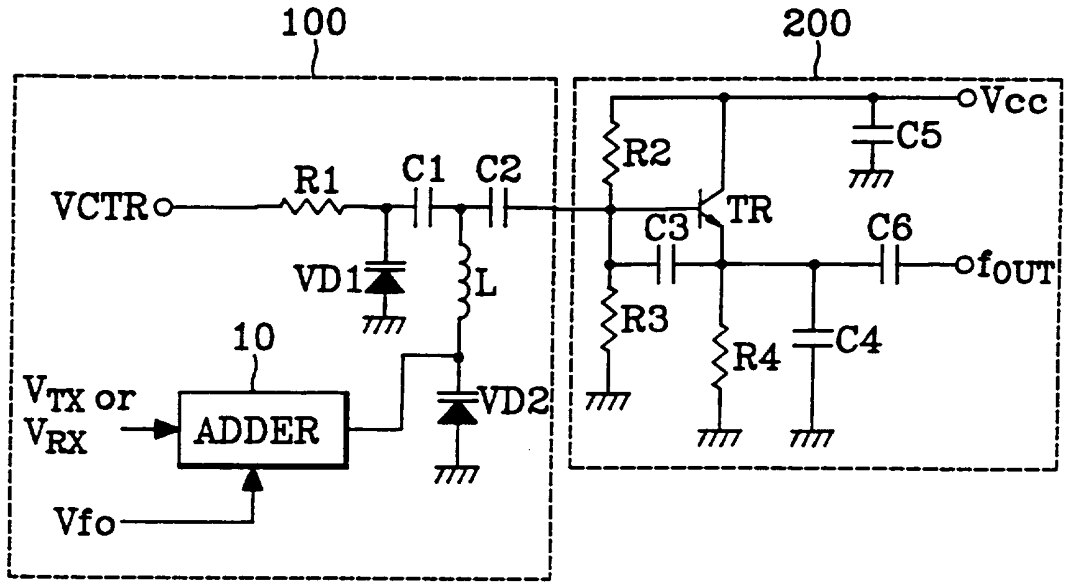
100
200
VCTR
R1
C1
C2
VD1
L
10
VTX or
VRX
ADDER
Vfo
VD2
R2
TR
Vcc
C5
C3
C6
fOUT
R3
R4
C4

Fig. 4

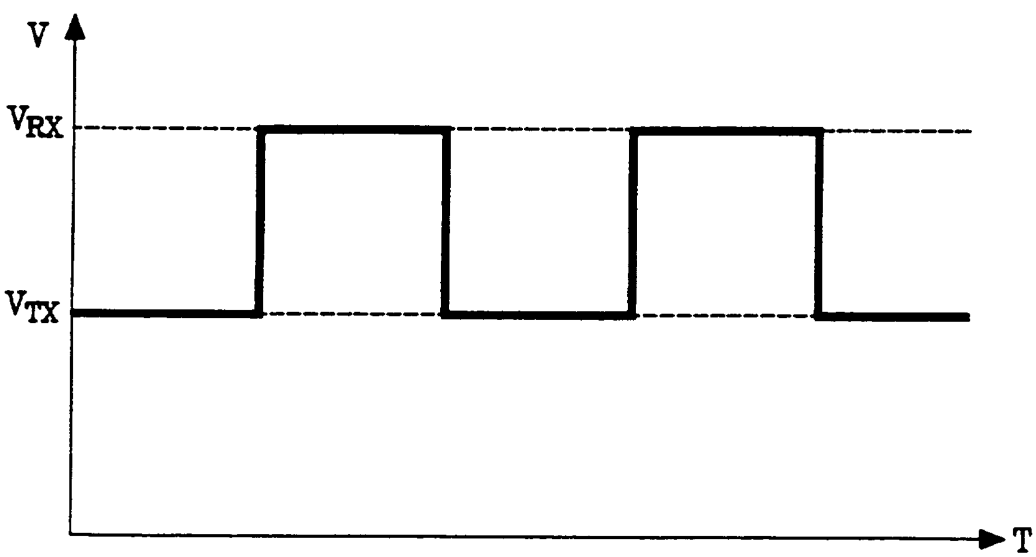
V
VRX
VTX
T

Fig. 5

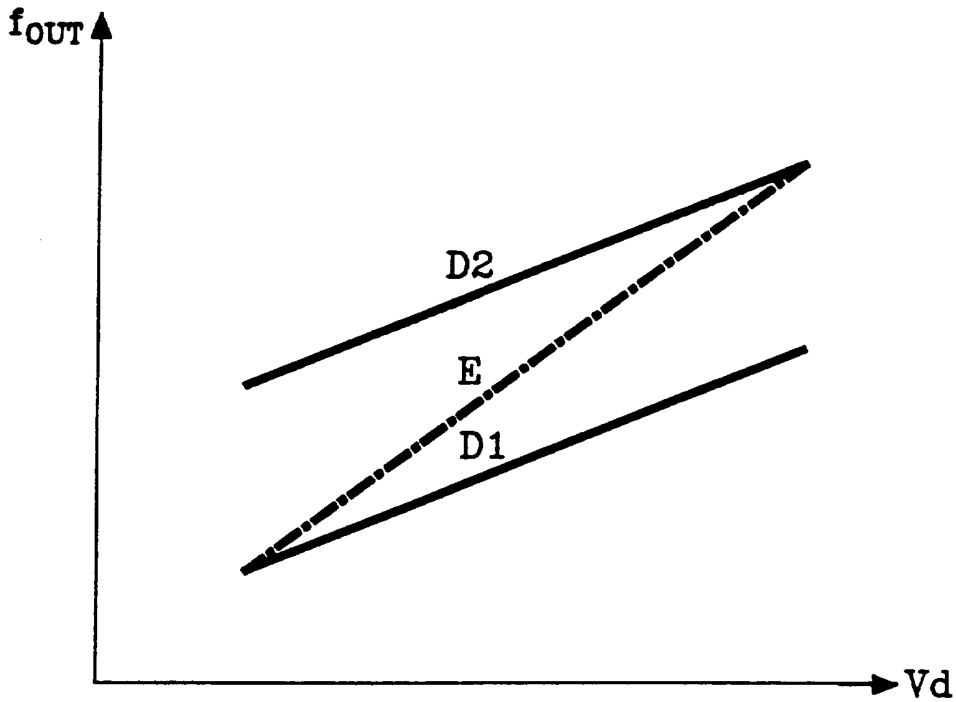
fOUT
D2
E
D1
Vd

Fig. 6

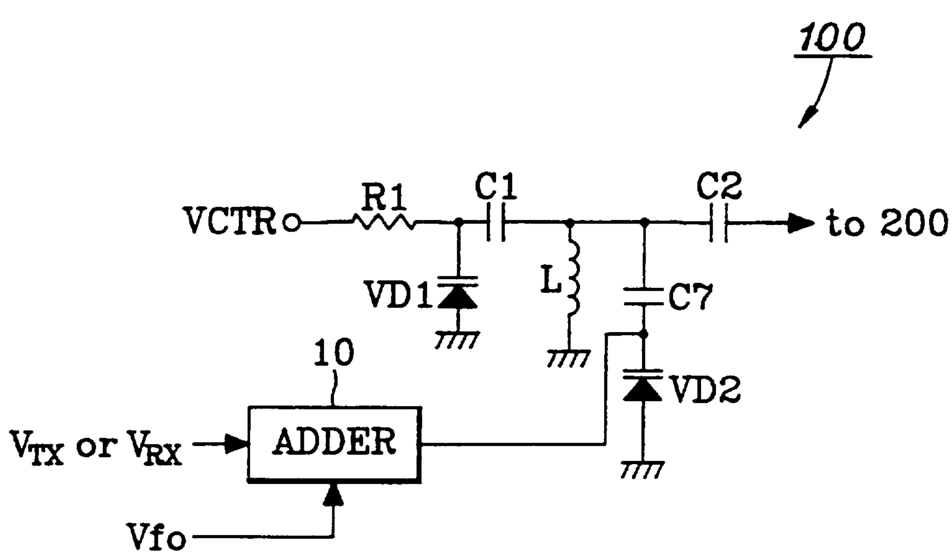
100
VCTR
R1
C1
C2
to 200
VD1
L
C7
VD2
10
ADDER
VTX or VRX
Vfo

Fig. 7

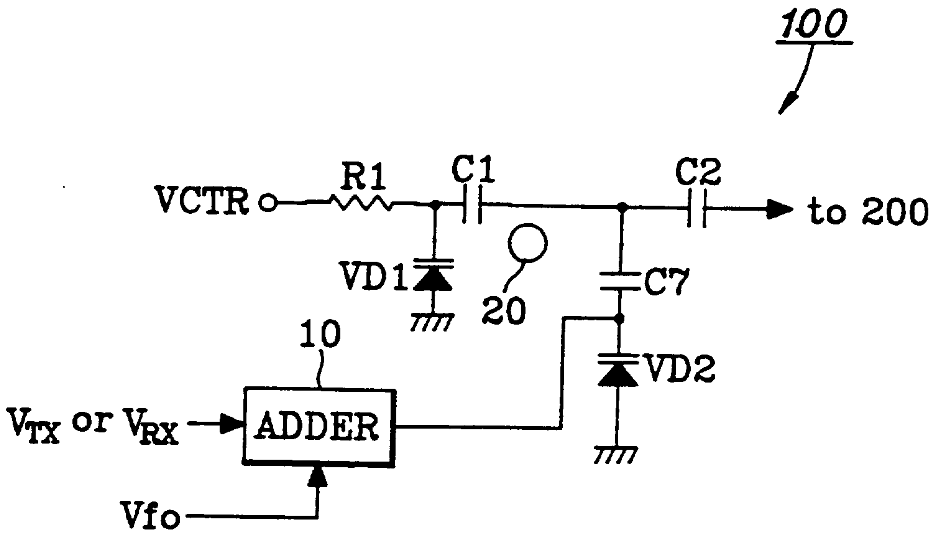
100
VCTR
R1
C1
C2
to 200
VD1
20
C7
10
VD2
V_{TX} or V_{RX}
ADDER
Vfo

Fig. 8

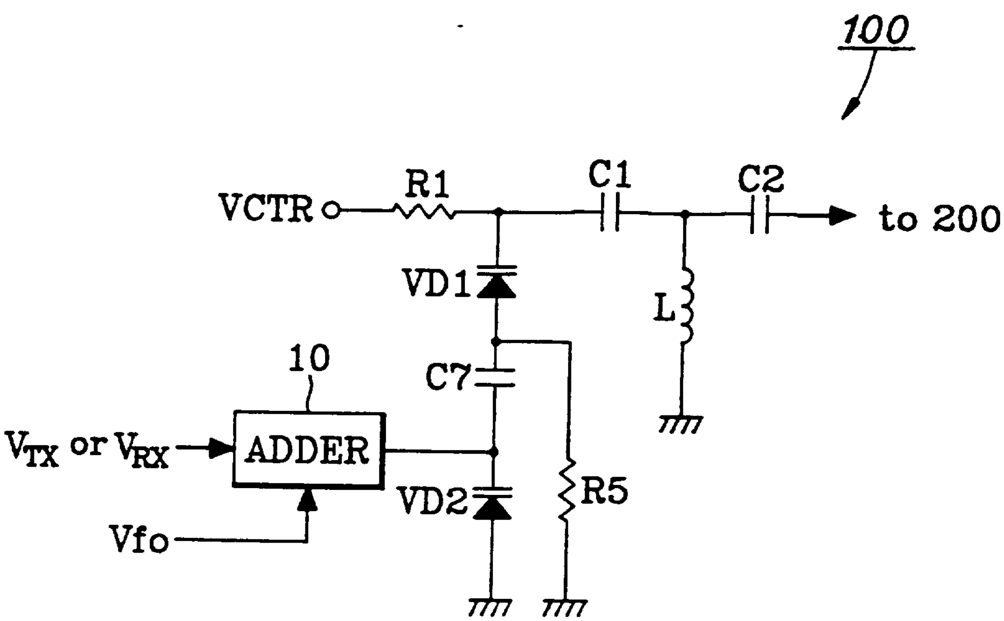
100
VCTR
R1
C1
C2
to 200
VD1
L
10
C7
V_{TX} or V_{RX}
ADDER
VD2
R5
Vfo

Fig. 9

VOLTAGE CONTROLLED OSCILLATORS

Field of the Invention

The present invention relates to a voltage controlled oscillator for an up/down-converter in a digital radio communication system.

Background to the Invention

In early radio communication systems frequency division multiple access of an analog format was used. However, recently code division multiple access (FDMA) or time division multiple access (TDMA) of a digital format have increasingly tended to be used in radio communication systems. For example, the global system for mobile communication (GSM), a representative digital communication system of the digital format, uses FDMA together with TDMA. That is, the GSM has separate transmitting and receiving frequencies. In other words, in a mobile station of the GSM, the range of transmitting frequency is 890-915Mhz and the range of the receiving frequency is 935-960MHz, which is higher by 45MHz than that of the transmitting frequency. Furthermore, the GSM is use to perform alternately the transmitting mode and the receiving mode within a frame, i.e., within a unit time.

The typical GSM includes two separate voltage controlled oscillators as a local oscillator for the up-converter which oscillates the transmitting frequency in the transmitting mode, and as a local oscillator for the down-converter which oscillates the receiving frequency in the receiving mode. The two separate voltage controlled oscillators (VCOs) used as the local oscillator for the up-converter and as the local oscillator for the down-converter output an oscillating frequency having a range which varies in proportion to an input control voltage. Therefore, the VCO requires the characteristic of linearly converting input control voltage to the oscillating frequency. Furthermore, the VCO is obliged to sufficiently cover a given frequency range. Hence, the VCO can be embodied using a variable capacitance diode, a multivibrator or a CMOS circuit.

FIG. 1 is a block diagram illustrating the construction of a known voltage controlled oscillator. In FIG. 1, an oscillating circuit makes use of a variable capacitance diode as a voltage variable reactance component. This VCO is known from figure 1 of Korean patent application no. 92-9028 and from figure 1 of Korean patent application No. 94-15043.

With reference to FIG. 1, showing a frequency resonator 2 and a negative resistance generator 4, a varactor diode VD, the capacitance of which varies in accordance with an applied control voltage VCTR, is series-connected with capacitor C1 to operate as a single variable capacitance component, and an inductor L is parallel-connected to the variable capacitance component. The frequency resonator 2 forms an LC parallel resonance circuit. Also, the negative resistance generator 4 is composed of a transistor TR and feedback capacitors C3 and C4, respectively connected between the emitter and base of the transistor TR and between the emitter and ground terminal. Here, the negative resistance generator 4 generates a resistance of the frequency resonator 2, i.e., a negative resistance for removing a power loss factor. In addition, the negative resistance generator 4 behaves as a kind of oscillating means for outputting an oscillating frequency f_{OUT} having the resonance frequency determined in the frequency resonator 2.

Regarding the construction of FIG. 1, R1 represents a resistor for coupling the control voltage VCTR to one variable capacitance component wherein the varactor diode VD is series-connected to the capacitor C1, and C2 represents a capacitor for coupling the LC parallel resonance circuit to the transistor TR. Moreover, R2 and R3 designate bias resistors for dividing the power supply voltage Vcc into voltages of a given level and supplying the divided voltage as a bias of the transistor TR. Also, R4 designates an emitter resistor of the transistor TR, C5 designates a capacitor connected between a collector of the transistor TR and the ground terminal, for removal of power noise, C6 designates a capacitor connected between the emitter of the transistor TR and an output terminal, for prevention of direct current DC, and f_{OUT} is the output of the VCO.

As can be seen in FIG. 1, when the control voltage VCTR is applied to the VCO constructed with the frequency resonator 2 and the negative resistance generator 4, the capacitance Cd of the varactor diode VD varies as the variation of a backward voltage Vd applied to an anode of the varactor diode VD. Thus, the resonant frequency of the LC parallel resonance circuit constructed with the varactor diode VD, the capacitor C1 and the inductor L, may be varied. As a result, the oscillating frequency f_{OUT} can be varied accordingly. The capacitance Cd of the varactor diode VD reduces in inverse proportion to the increment of the backward voltage Vd applied to the anode of the varactor diode VD. FIG. 2 shows a characteristic curve illustrating variations in capacitance of a varactor diode as a function of the Vd.

In the GSM, the VCO operated as mentioned above may be used as the local oscillator for an up-converter and as the local oscillator for a down-converter. However, the VCO has recently tended to be embodied using two VCOs, i.e. the VCO for the up-converter and the VCO for the down-converter, combined into a single VCO, to reduce the overall dimensions of the system and for reasons of economics. Korean patent application no. 95-8687 discloses a single VCO for the up-converter and the down-converter, as described. In the aforesaid application, the single VCO is used as the local oscillator for the up-converter during signal transmission and as the local oscillator for the down-converter upon signal reception.

However, to use the prior art VCO shown in FIG. 1 as the local oscillator for down-converter/up-converter, the range of variations in the oscillating frequency has to be increased sufficiently to cover all of the transmitting frequency bandpass and the receiving frequency bandpass. For instance, when the characteristics of the variations in the output frequency versus the control voltage VCTR in the VCO used as the local oscillator for the up-converter is as shown by curve A1 of FIG. 3A, the range of variations in the oscillating frequency f_{OUT} in the VCO used as the local oscillator for the up/down-converter must be increased as shown by curve A2 of FIG. 3A. Meantime, when the characteristics of the variations in the output frequency versus the control voltage VCTR in the VCO used as the local oscillator for the down-converter is as shown by curve B1 of FIG. 3B, the range of variations in the oscillating frequency f_{OUT} in the VCO used as the local oscillator for the up/down-converter must be increased as shown by curve B2 of FIG. 3B.

For the purpose of increasing the range of variations in the oscillating frequency f_{OUT} in the VCO as shown in FIG. 1, one can increase the capacitance of the capacitor C1. US patent no. 5144264 discloses another way of increasing the range of variations in the oscillating frequency f_{OUT} of the VCO. Inasmuch as the frequency resonator of the VCO disclosed in the aforementioned US patent has two parallel-coupled varactor diodes, upon applying the control voltage VCTR to the frequency resonator of the VCO, the range of variations in the oscillating frequency thereof may be increased.

If the range of variations in the oscillating frequency is increased by increasing the capacitance of the capacitor C1 or by parallel-connecting two varactor diodes, noise caused by external factors may be included in the control voltage VCTR, so that the oscillating frequency can easily be swung. Eventually, this results in deterioration of the phase noise characteristics of the VCO.

The above US patent has a construction which compensates for deterioration in phase noise characteristics due to the increase of the range of variations in the oscillating frequency. Namely, when the range of variations in the oscillating frequency changes, the impedance of the frequency resonator does not conform with that of the negative resistance generator. For the sake of matching the impedance of the frequency resonator with that of the negative resistance generator, an LC series resonance circuit is constructed in a feedback unit of the negative resistance generator disclosed in the above US patent. In this construction, the range of variations in the oscillating frequency can be increased and the phase noise characteristics of the VCO can be improved. However, the factor which enables the phase noise characteristics to deteriorate cannot be fundamentally reduced.

It is therefore an object of the present invention to provide a voltage controlled oscillator for an up/down-converter with improved phase noise characteristics.

It is another object of the present invention to provide a voltage control oscillator for an up/down-converter which is capable of attaining a desirable oscillating frequency without increasing the range of variations in the oscillating frequency.

Summary of the Invention

Thus, according to the present invention, there is provided a voltage controlled oscillator for an up/down-converter in a digital radio communication system comprising:

a resonance unit having a resonance point which depends upon an applied control voltage and an applied mode voltage; and

an oscillating unit for oscillating at a frequency corresponding to the resonance point of the resonance unit.

Preferably, the resonance unit includes:

a first variable capacitance component having a capacitance dependent upon the level of the applied control voltage;

a second variable capacitance component having a capacitance dependent upon the level of the applied mode voltage; and

an inductive component;

and the first and second variable capacitance components and the inductive component are connected to one another with the inductive component connected in parallel with at least one of the variable capacitance components.

According to a first preferred embodiment of the present invention, the resonance unit includes:

a first variable capacitance component having a capacitance dependent upon the level of an applied control voltage; and

a series resonance circuit connected in parallel with the variable capacitance component and having a series resonance point dependent upon the level of an applied mode voltage.

The series resonance circuit may comprise:

a second variable capacitance component having a capacitance dependent upon the applied mode voltage; and

an inductive component connected in series to the varactor diode in parallel to the said variable capacitance component.

According to a second preferred embodiment of the present invention, the resonance unit includes:

a first variable capacitance component having a capacitance dependent upon the level of the applied control voltage;

a second variable capacitance component having a capacitance dependent upon the level of the applied mode voltage; and

an inductive component;

and the first and second variable capacitance components and the inductive component are connected to one another with the inductive component connected in parallel with the second variable capacitance component.

According to a third preferred embodiment of the present invention, the resonance unit includes:

a first variable capacitance component having a capacitance dependent upon the level of the applied control voltage;

a second variable capacitance component having a capacitance dependent upon the level of the applied mode voltage; and

an inductive component;

and the first and second variable capacitance components are connected to one another in series to form a series connecting circuit and the inductive component is connected in parallel with the series connecting circuit.

The second variable capacitance component may be a varactor diode.

Preferably, the capacitance of the second variable capacitance component also depends upon an applied adjusting voltage. In this case, the oscillator may further comprise a summation unit for summing the adjusting voltage and the applied mode voltage and applying the summed voltage to the second variable capacitance component.

Preferably, the capacitance of the first variable capacitance component is inversely proportional to the level of the applied control voltage in a preset range. Similarly, it is preferred that the capacitance of the second variable capacitance component be inversely proportional to the level of the applied mode voltage in a preset range.

The inductive component may be an inductor or it may be a dielectric resonator.

Brief Description of the Drawings

The present invention will now be described by way of example with reference to the accompanying drawings in which:

FIG. 1 is a block diagram illustrating the construction of a known voltage controlled oscillator;

FIG. 2 shows a characteristic curve illustrating variations in capacitance of a varactor diode as a function of the control voltage applied to the frequency resonator of FIG. 1;

FIGs. 3A and 3B show characteristic curves illustrating variations in an oscillating frequency as a function of the control voltage applied to the frequency resonator of FIG. 1;

FIG. 4 is a block diagram illustrating the construction of a voltage controlled oscillator according to a first embodiment of the present invention;

FIG. 5 is a diagram illustrating variations in the mode voltage applied to the adder of FIG. 4 in accordance with the active mode;

FIG. 6 shows a characteristic curve illustrating variations in an oscillating frequency as a function of the control voltage applied to the frequency resonator of FIG. 4;

FIG. 7 is a block diagram illustrating the construction of a voltage controlled oscillator according to a second embodiment of the present invention;

FIG. 8 is a block diagram illustrating the construction of a voltage controlled oscillator according to a third embodiment of the present invention; and

FIG. 9 is a block diagram illustrating the construction of a voltage controlled oscillator according to a fourth embodiment of the present invention.

Detailed Description of the Invention

FIG. 4 is a block diagram illustrating a VCO according to a first embodiment of the present invention. It includes a frequency resonator 100 and a negative resistance generator 200. In contrast with the known VCO shown in FIG. 1, the frequency resonator 100 in the VCO according to the present invention is different from the known frequency resonator 2 whereas the negative resistance generator 200 is the and the known negative resistance generator 4. Referring to FIG. 4, capacitor C1 and a varactor diode VD1 in the frequency resonator 100 construct a variable capacitance component having a capacitance inversely proportional to the control voltage VCTR. An inductor L and a varactor diode VD2 construct a series resonance circuit having a series resonance point which varies in accordance with the voltage output from an adder 20. This frequency resonator 100 is a parallel resonance circuit.

FIG. 5 is a diagram illustrating variations in the mode voltage applied to the adder of FIG. 4 in accordance with the active mode, in which a transmitting mode voltage V_{TX} and a receiving mode voltage V_{RX} are alternately applied.

FIG. 6 shows a characteristic curve illustrating variations in oscillating frequency f_{OUT} as a function of the control voltage VCTR applied to the frequency oscillator of FIG. 4.

When the control voltage VCTR is applied to the varactor diode VD1 through resistor R1, the capacitance of the varactor diode VD1 as shown by the characteristic curve of FIG. 2 varies in inverse proportion to the applied control voltage VCTR. A second varactor diode VD2 also varies in capacitance in inverse proportion to the applied mode voltage. In the frequency resonator 100 of FIG. 4, an inductor L and the varactor diode VD2 form the series resonance circuit, and the series resonance circuit, the capacitor C1, and the varactor diode VD1 are connected in parallel with one another, thereby forming the parallel resonance circuit. While the inductor L of the series resonance circuit may use a coil at low frequency, it can also use a microstrip line or strip line at high frequency. Conventionally, in digital radio communication systems, a micro strip line or strip line is utilized as the inductor L. In the parallel resonance circuit formed as described above, when the capacitance of the varactor diode VD1 is varied by the control voltage VCTR, the parallel resonance point of the frequency resonator 100 also varies as does the oscillating frequency f_{OUT} of the negative resistance generator 200.

With increases of the capacitance of the capacitor C1 in the frequency resonator 100, the range of variations in the oscillating frequency f_{OUT} due to the applied control voltage VCTR is increased. To the other hand, with decreases of the capacitance of the capacitor C1 in the frequency resonator 100, the range of variations in the oscillating frequency f_{OUT} is decreased by reducing the variation of the capacitance of the varactor diode VD1 due to the applied control voltage VCTR. That is, the range of variations in the oscillating frequency f_{OUT} of the VCO is mainly due to the capacitance of the capacitor C1. Also, the series resonance circuit constructed with the inductor L and the varactor diode VD2, enables the oscillating frequency f_{OUT} in the VCO to be varied with the variation of the series resonance point due to the variation of the capacitance of the varactor diode VD2. The voltage applied to the varactor diode VD2 is an output (V_{TX} or V_{RX}) from an adder 10. Herein, V_{fo} designates the voltage for fine adjustment of the oscillating frequency f_{OUT} and V_{TX} or V_{RX} designates the voltage for switching a central frequency in the VCO in the transmitting and receiving modes.

As shown in FIG. 5, the voltage $V_{TX}+V_{fo}$ in the transmitting mode is applied through the adder 10 to the varactor diode VD2 and the voltage $V_{RX}+V_{fo}$ in the receiving mode is applied through the adder 10 to the varactor diode VD2. Thus, a capacitance corresponding to the voltage applied in each mode is generated. Consequently, while the series resonance circuit composed of the inductor L and the varactor diode VD2 in the transmitting mode has a resonance point corresponding to the transmitting mode, the series resonance circuit in the receiving mode has a resonance point corresponding to the receiving mode. In other words, the series resonance frequency is different according to the transmitting or receiving mode. For this reason, since the capacitance of the varactor diode VD1 varies with the control voltage VCTR, the characteristic curve of the variations in the oscillating frequency f_{OUT} versus the backward voltage is obtained as shown by curves D1 and D2 of FIG. 6.

With respect to FIG. 4, the negative resistance generator 200 is connected to the frequency resonator 100 through coupling capacitor C2, capacitors C3 and C4 designate feedback capacitors, and resistors R2, R3 and R4 designate bias resistors of the transistor TR, capacitor C6 being provided to prevent DC direct current power and capacitor C5 being provided to remove noise from the power supply voltage Vcc. The oscillating frequency f_{OUT} is determined by a combination of the frequency resonator 100 and the negative resistance generator 200.

As described above, in the digital radio communication system such as the GSM which uses the TDMA and separate transmitting and receiving frequencies, when using the VCO as the local oscillator for up/down-converter, the characteristic curve of the variations in the oscillating frequency versus the control voltage applied to the VCO is shown by curves D1 and D2 of FIG. 6. Consequently, the ranges of frequency used in the transmitting mode and the receiving mode are different. That is to say, the curve D1 of FIG. 6 corresponds to the characteristic curve of the variations in the oscillating frequency versus the control voltage in the transmitting mode and the curve D2 of FIG. 6 corresponds to the characteristic curve of the variations in the oscillating frequency versus the control voltage in the receiving mode. In the GSM, in the case that an intermediate frequency for transmission is 264MHz and the range of the transmitting frequency is 890-915MHz, the local oscillating frequency for the up-converter requires variations in frequency corresponding to 264MHz + (890-915MHz) = 1154-1179MHz. Also, in the case that an intermediate frequency for reception is 244MHz and the range of the receiving frequency is 935-960MHz, the local oscillating frequency for the down-converter requires variations in frequency corresponding to 244MHz + (935-960MHz) = 1179-1204MHz. Accordingly, to use the VCO as the local oscillator for the up/down-converter, variations in frequency corresponding to 1154-1204MHz are required.

When using the known VCO depicted in FIG. 1 as the local oscillator for the up/down-converter, variations in frequency having an increased range as shown by curve E of FIG. 6 are required. However, as depicted in FIG. 4, when using the VCO according to the present invention as the local oscillator for the up/down-converter, variations in frequency having a range narrower than that in curve E of FIG. 6 may be used as shown by curves D1 and D2 of FIG. 6. If the range of the variations in frequency is broad, variations in frequency can easily be influenced by external noise, resulting in deteriorations in phase noise characteristics. However, because the present invention uses narrower ranges of variations in frequency, the phase noise characteristics are improved.

FIG. 7 is a block diagram illustrating the construction of a VCO according to a second embodiment of the present invention. Herein, the capacitor C1 and the varactor diode VD1 constitute the variable capacitance component, the capacitor C7 and the varactor diode VD2 constitute another variable capacitance component, and the inductor L is connected in parallel with the variable capacitance components. Eventually, the frequency resonator 100 forms the parallel resonance circuit.

Regarding FIG. 7, the control voltage VCTR is applied to the varactor diode VD1, the capacitance of which is determined in correspondence with the applied control voltage VCTR. The capacitance of the varactor diode Vd1 is inversely proportional to the control voltage VCTR. In addition, the adder 10 adds a minute adjusting voltage V_{fo} to the transmitting mode voltage V_{TX} or the receiving mode voltage V_{RX}, the result being applied to the varactor diode VD2. In this case, the capacitance of the varactor diode VD2 is inversely proportional to the output voltage of the adder 10. As described above, since the capacitances of the varactor diodes are determined by the control voltage VCTR and the output voltage of the adder 10, and the resonance point of the parallel resonance circuit is determined by the inductance of the inductor L, the negative resistance generator 200 oscillates at an oscillating frequency f_{OUT} corresponding to the determined resonance point.

FIG. 8 is a block diagram illustrating the construction of a VCO according to a third embodiment of the present invention. As illustrated in the circuit of FIG. 7, the capacitor C1 and the varactor diode VD1 constitute the variable capacitance component, and the capacitor C7 and the varactor diode VD2 constitute another variable capacitance component. However, a dielectric resonator 20 as an inductive component is parallel-connected to the variable capacitance components, thereby forming a parallel resonance circuit. As before, use of the dielectric resonator 20 instead of the inductor L is well known in the field of the present invention. In this instance, the operational characteristics of the VCO are similar to those of FIG. 7.

FIG. 9 is a block diagram illustrating the construction of a VCO according to a fourth embodiment of the present invention, wherein the capacitor C1, the varactor diode VD1, the capacitor C7 and the varactor diode VD2 are series-connected to one another, thereby forming a series connecting circuit. The inductor L1 is parallel-connected to the series connecting circuit, and the resistor R5 is parallel-connected to the varactor diode VD2 and the capacitor C7. Finally, the frequency resonator 100 forms a parallel resonance circuit.

As can be seen in FIG. 9, the adder 10 adds the minute adjusting voltage V_{f_0} to the transmitting mode voltage V_{TX} or the receiving mode voltage V_{RX}, the result being applied to the varactor diode VD2. In this case, the capacitance of the varactor diode VD2 is determined by the output voltage of the adder 10. The capacitance of the varactor diode VD2 is inversely proportional to the output voltage of the adder 10. As stated above, the control voltage VCTR is applied to the varactor diode VD1. Then, the capacitance of the varactor diode VD1 is determined by the applied control voltage VCTR. The capacitance of the varactor diode VD1 is inversely proportional to the control voltage VCTR, so that the capacitor C1, the varactor diode VD1, the capacitor C7, and the varactor diode VD2 can be determined accordingly. Again, since the parallel resonance point of the parallel resonance circuit is determined by the inductance of the inductor L and the capacitance, the negative resistance generator 200 oscillates at an oscillating frequency f_{OUT} corresponding to the determined parallel resonance point.

In the fourth embodiment as shown in FIG. 9, the present invention can be embodied using the dielectric resonator of FIG. 8 instead of the inductor L.

As apparent from the foregoing, the present invention is advantageous that the local oscillating frequency for transmission/reception which is required in each mode can be output by applying the voltage indicative of the transmitting mode or the reception mode, without increasing the range of variations in the oscillating frequency.

CLAIMS:

1. A voltage controlled oscillator for an up/down-converter in a digital radio communication system comprising:

a resonance unit having a resonance point which depends upon an applied control voltage and an applied mode voltage; and

an oscillating unit for oscillating at a frequency corresponding to the resonance point of the resonance unit.

2. An oscillator according to claim 1 in which the resonance unit includes:

a first variable capacitance component having a capacitance dependent upon the level of the applied control voltage;

a second variable capacitance component having a capacitance dependent upon the level of the applied mode voltage; and

an inductive component;

in which the first and second variable capacitance components and the inductive component are connected to one another with the inductive component connected in parallel with at least one of the variable capacitance components.

3. An oscillator according to claim 1 or claim 2 in which the resonance unit includes:

a first variable capacitance component having a capacitance dependent upon the level of an applied control voltage; and

a series resonance circuit connected in parallel with the variable capacitance component and having a series resonance point dependent upon the level of an applied mode voltage.

4. An oscillator according to claim 3 in which the series resonance circuit comprises:

a second variable capacitance component having a capacitance dependent upon the applied mode voltage; and an inductive component connected in series to the varactor diode in parallel to the said variable capacitance component.

5. An oscillator according to claim 2 in which the second variable capacitance component and the inductive component are connected in parallel.

6. An oscillator according to claim 2 in which the first and second variable capacitance components are connected to one another in series to form a series connecting circuit and the inductive component is connected in parallel with the series connecting circuit.

7. An oscillator according to any one of claims 2 and 4-6 in which the second variable capacitance component is a varactor diode.

8. An oscillator according to any one of claims 2 and 4-7 in which the capacitance of the second variable capacitance component also depends upon an applied adjusting voltage.

9. An oscillator according to claim 8 further comprising a summation unit for summing the adjusting voltage and the applied mode voltage and applying the summed voltage to the second variable capacitance component.

10. An oscillator according to any one of claims 2-9 in which the capacitance of the first variable capacitance component is inversely proportional to the level of the applied control voltage in a preset range.

11. An oscillator according to any one of claims 2 and 4-9 in which the capacitance of the second variable capacitance component is inversely proportional to the level of the applied mode voltage in a preset range.

12. An oscillator according to any one of claims 2 and 4-9 in which the inductive component is an inductor.

13. An oscillator according to any one of claims 2 and 4-9 in which the inductive component is a dielectric resonator.

14. A voltage controlled oscillator for an up/down-converter in a digital radio communication system substantially as described herein with reference to FIGs. 4-6, FIG. 7, FIG. 8 or FIG. 9 of the accompanying drawings.

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Claims searched:	1-14	**Date of search:**	21 October 1996

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H3F (FJAA,FJX); H3R (RFMA)

Int Cl (Ed.6): H03B 5/12

Other: ONLINE:WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	US 4494081 (RCA)	1-5,7,10-13
X	US 3813615 (Alps)	1-5,7,10-13

X Document indicating lack of novelty or inventive step
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