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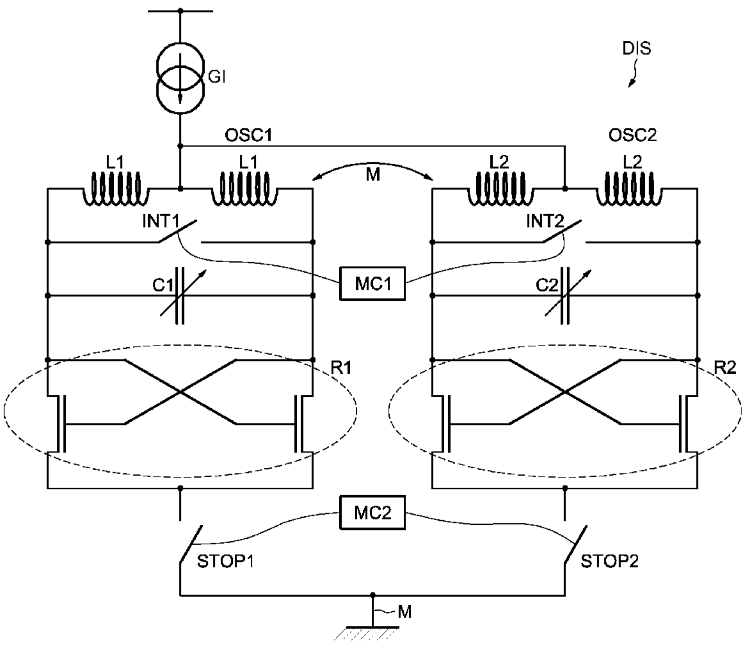
(54) **Title**: MULTI-BAND FREQUENCY OSCILLATING DEVICE

FIG.2



(57) **Abstract**: Oscillating device comprising several oscillators (OSC1, OSC2), each oscillator comprising a capacitive inductive resonant circuit (L 1 & C1, L2 & C2) and a flow-through conduction circuit (G1, G2) having a negative flow-through conduction, the inductive elements of the oscillators being mutually coupled. Each oscillator also comprises a controllable switch (INT 1, INT2) arranged in order to short-circuit or not short-circuit the capacitive element of the oscillator (C1, C2) and in that the device also comprises controllable commutating means (STOP1, ST0P2) arranged to activate one oscillator at a time.

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Multi-band frequency oscillating device

The present invention relates to the field of electronics and more particularly the field of oscillators the frequency of which is tunable. Advantageously, but not limitingly, the invention applies to communication systems using such oscillators, for example cellular mobile telephones.

The increasing number of communication standards and the centralization of all these standards within a single portable communication apparatus are difficult to achieve. Specifically, in order to transmit and receive on each of the bands concerned by these standards an oscillating element capable of operating continuously on all these frequency bands must be used. An oscillating element comprising a juxtaposition of several oscillating circuits does not allow a continuous operation between the frequency bands. Another oscillating element comprising a single oscillator with a tunable frequency does not allow a sufficient amplitude of frequency variation.

A chosen solution usually consists in the use of a single circuit supplying several oscillators, making operation possible on several bands. The use of a single circuit also makes it possible to reduce costs and make miniaturization of the electronic circuit easier.

In this type of circuit, the induction coils of each of the oscillators may also be mutually coupled electromagnetically. Therefore, in patents US7423495 and WO06/0200873, several oscillating circuits are mutually coupled via induction coils. The values of the induction coils vary depending on the modes of the other oscillators and this makes it possible to multiply the number of operating modes.

According to one embodiment, it is proposed, without increasing the number of oscillators or the number of components, to allow a continuous operation over a broad band of frequencies with operating modes that are yet more numerous and a greater variation of impedances and capacitors during these operating modes.

According to another embodiment, an oscillating device is proposed that provides low consumption and minimum phase noise by tuning via an adjustment of the induction coil and of the capacitor, and not of the capacitor alone.

Also proposed in particular is a continuity between the operating bands of the various oscillators notably by a sharing of elements (earth, the intensity generator, the bias).

According to a first aspect, an oscillating device is proposed comprising several oscillators, each oscillator comprising a capacitive inductive resonant circuit and a flow-through conduction circuit having a negative flow-through conduction, the inductive elements of the oscillators being mutually coupled.

According to a general feature of this aspect, each oscillator also comprises a controllable switch arranged to short-circuit or not short-circuit the capacitive element of the oscillator and the device also comprises controllable commutating means arranged to activate one oscillator at a time.

Therefore, on the one hand, added to the operating modes of each of the oscillators taken separately are combined operating modes covering other frequency bands. On the other hand, amongst these combined operating modes, operating modes corresponding to the short-circuited capacitor in each of the oscillators are added. The added operating modes make it possible to vary the value of capacitance and therefore also inductance over a very wide range, the amplitude of frequency is therefore greater. Moreover, by tuning via an adjustment of more numerous parameters, i.e. inductance and capacitance, it is possible to optimize each of these parameters in order to obtain low consumption and minimum phase noise.

According to one embodiment, the controllable switch of each oscillator is connected in parallel to the capacitive element of the oscillator.

According to another embodiment, the oscillating device comprises first control means capable of short-circuiting the capacitive element of at least one oscillator that is not activated.

The great variation of capacitance may, if it follows a short circuit in the inactive oscillator, allow a variation of inductance in the active oscillator.

According to an additional embodiment, the first commutating means comprise several commutators respectively connected between the flow-through conduction circuits of the oscillators and a common earth terminal and the device comprises second control means capable of closing only one commutator at a time.

This allows continuity between the operating bands of the oscillators sharing the same elements.

According to a final embodiment, the inductive elements of the oscillators are superposed on one another.

Therefore, by creating magnetic coupling via a superposition of the induction coils, a gain in surface area is achieved. This gain in surface area allows a lower frequency-pulling effect (caused by another signal being coupled to the induction coils of the oscillator).

Other advantages and features of the invention will appear on studying the detailed description of methods of application and embodiment taken as non-limiting examples and illustrated by the appended drawings in which:

- Figure 1 illustrates a simple circuit comprising two coupled oscillators.

- Figure 2 illustrates an example of a circuit comprising two oscillators and two negative flow-through conductors.

Figure 1 shows an oscillator the two inductive elements of which are coupled. This simple circuit makes it possible to establish equations governing the behaviour of the mutually coupled inductive elements.

The first oscillator comprises a resistor R1, a capacitor C1 and a coil L1. Similarly, the second circuit comprises a resistor R2, a capacitor C2 and a coil L2. The two circuits are coupled electromagnetically via the two coils L1 and L2 with a mutual coefficient of inductance M.

Therefore, the voltages V1 and V2 and the intensities i1 and i2 follow the conditions below expressed in complex notation:

V1=j.L1.w.I1+ j.M.w.I2

V2=j.L2.w.I2+ j.M.w.I1

where $|M| = k \cdot \sqrt{L1 \cdot L2}$, k is the coupling coefficient depending in particular on the mutual arrangement of the coils.

In the particular case in which V2=0, that is to say when the capacitor C2 is short-circuited:

I2=-(M/L2).I1

Therefore, seen from R1, the complex impedance in the first oscillator is equivalent to a capacitor C1 in parallel with a coil the induction of which is equal to L1.(1-k^2).

If there is no short circuit, V2 can be expressed in the form:

V2= -I2/(C2.j.w), and

I2=I1.(C2.M.w^2)/(1-L2.C2.w^2).

Therefore, seen from R1, the complex impedance in the first oscillator is equal to a capacitor in parallel with a coil the induction of which is: L1.(1-k^2.L2.C2.w^2/(L2.C2.w^2-1)).

Figure 2 illustrates an example of a device DIS according to the invention. The latter comprises an intensity generator GI, two oscillators OSC1 and OSC2 and an earth terminal M. This being so, the invention is not limited to two oscillators but may comprise several oscillators mutually coupled by their respective induction coils.

Each of the two oscillators comprises a mid-point to which two induction coils L1 & L1 or L2 & L2 are connected. Each of the induction coils L1 or L2 is mutually coupled with one of the induction coils L2 or L1 respectively. In parallel with the two induction coils there are first of all a switch INT1 or INT2 and a variable and adjustable capacitor C1 or C2. When the switch INT1 or INT2 is closed, respectively the capacitor C1 or C2 is short-circuited. In addition, in parallel with the two induction coils, in each oscillator there is a flow-through conduction circuit G1 or G2 having a negative flow-through conduction. The negative flow-through conduction makes it possible to compensate for the losses and to maintain the oscillations. The operation of each of the flow-through conduction circuits may be optimized for the frequency bands of each of the oscillators. Each flow-through conduction circuit is formed in this instance for example of two MOS transistors of which the two links to the gate are crossed.

Each of the two oscillators is also connected via a commutator STOP1 or STOP2 to the earth terminal M. They may therefore be activated/deactivated by the commutating means STOP1 and STOP2. When the commutator STOP1 or STOP2 is closed, respectively the oscillator OSC1 or OSC2 is activated.

The circuit illustrated in Figure 2 also comprises control means MC2 capable of controlling the commutating means (STOP1, STOP2) so that only one of the oscillators is active. Finally, means MC1 are capable of controlling the switches INT1 and INT2. The means MC1 and MC2 collaborate so that only the capacitor of an inactive oscillator can be short-circuited. The control means MC1, MC2 can be produced for example based on logic circuits.

The considerable number of parameters that can be adjusted (value of inductance, value of coupling, value of the capacitors, size of the flow-through conduction circuits) allows a sufficient number of degrees of freedom to make possible an effective optimization of each of the oscillators. Therefore, it is in particular possible to adjust these parameters so as to obtain a superposition of all the frequency bands and good performance with respect to phase noise and power consumption.

Moreover, the short-circuiting of the capacitors C1 and C2 in respectively the oscillator OSC1 and OSC2 makes it possible to add operating modes that are then six in number, each making it possible to cover a frequency band. The calculations of the values of the induction coils after they are coupled in the circuit of Figure 1 can apply to the circuit of Figure 2 and therefore:

- Mode 1: Oscillator active: OSC2, value of inductance after coupling in OSC2: $L2.(1-k^2.L1.C1.w^2/(L1.C1.w^2-1))$, value of C1 close to its minimum and C2 varies from its minimum value to half of its maximum value. The band covered by the specific frequency then ranges from 6.3 to 7 GHz.

- Mode 2: Oscillator active: OSC2, value of the induction coil $L2.(1-k^2.L1.C1.w^2/(L1.C1.w^2-1))$, value of C1 at its maximum and C2 varies from its minimum value to its maximum value. The band covered by the specific frequency then ranges from 5.6 to 6.8 GHz.

- Mode 3: Oscillator active: OSC2, C1 is short-circuited, value of inductance after coupling in OSC2: $L2.(1-k^2)$ and C2 varies from its minimum value to its maximum value. The band covered by the specific frequency then ranges from 5.1 to 6.5 GHz.

- Mode 4: Oscillator active: OSC1, C2 is short-circuited, value of inductance after coupling in the active oscillator: $L1.(1-k^2)$ and C1 varies from its minimum value to its maximum value. The band covered by the specific frequency then ranges from 3.8 to 5.4 GHz.

- Mode 5: Oscillator active: OSC1, value of inductance after coupling in the active oscillator: $L1.(1-k^2.L2.C2.w^2/(L2.C2.w^2-1))$, C1 varies from the minimum value to its maximum value and value of C2 close to its minimum. The band covered by the specific frequency then ranges from 3.2 to 4.2 GHz.

- Mode 6: Oscillator active OSC1, value of inductance after coupling in the active oscillator: $L1.(1-k^2.L2.C2.w^2/(L2.C2.w^2-1))$, C1 varies from its minimum value to its maximum value and value of C2 close to its maximum. The band covered by the specific frequency then ranges from 3 to 3.5 GHz.

The frequency band values have been obtained with capacitors and induction coils having the following values L1 = 750 pH, C1 = 3.2 pF (maximum value), L2 = 510 pH, C2 = 4.2 pF (maximum value).

The invention as described allows the production of an oscillator of which the variation of specific frequency is of the order of +/-40% around 5 GHz. The best oscillators LC according to the prior art allow variations of +/-30% around 4.5 GHz.

Compared with a conventional solution that uses two oscillators to cover the same frequency band, the invention also allows a gain in surface area by creating the magnetic coupling by superposition of the induction coils on one another. This gain in surface area allows a lower frequency-pulling effect (caused by another signal being coupled to the induction coils of the oscillator). Overall, the invention makes it possible to take advantage of the coupling between the coils instead of installing devices in order to avoid it.

The invention also makes it possible to have a single oscillating device capable of covering, for example, the frequency bands of the GSM, DCS, TDD-WCDMA, FDD-WCDMA standards required for the operation of current cellular mobile telephones with a sufficiently low phase noise to be compatible with the specifications required by these communication standards.

CLAIMS

1. Oscillating device comprising several oscillators (OSC1, OSC2), each oscillator comprising a capacitive inductive resonant circuit (L1 & C1, L2 & C2) and a flow-through conduction circuit (G1, G2) having a negative flow-through conduction, the inductive elements of the oscillators being mutually coupled, characterized in that each oscillator also comprises a controllable switch (INT1, INT2) arranged to short-circuit or not short-circuit the capacitive element of the oscillator (C1, C2) and in that the device also comprises controllable commutating means (STOP1, STOP2) arranged to activate one oscillator at a time.

2. Oscillating device according to Claim 1, in which the controllable switch (INT1, INT2) of each oscillator (OSC1, OSC2) is connected in parallel to the capacitive element (C1, C2) of the oscillator.

3. Oscillating device according to Claim 1 or 2, comprising first control means (MC1) capable of short-circuiting the capacitive element (C1, C2) of at least one oscillator (OSC1, OSC2) that is not activated.

4. Oscillating device according to Claim 2 or 3, in which the first commutating means comprise several commutators (STOP1, STOP2) respectively connected between the flow-through conduction circuits of the oscillators (G1, G2) and a common earth terminal (M) and the device comprises second control means (MC2) capable of closing only one commutator (STOP1, STOP2) at a time.

5. Oscillating device according to any one of the preceding claims, in which the inductive elements of the oscillators are superposed on one another.

FIG.1

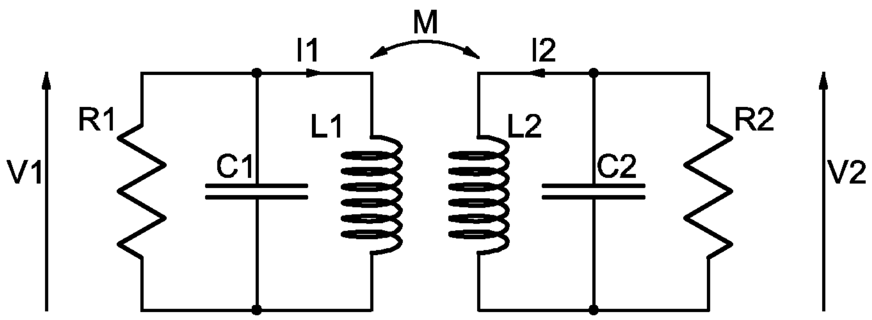
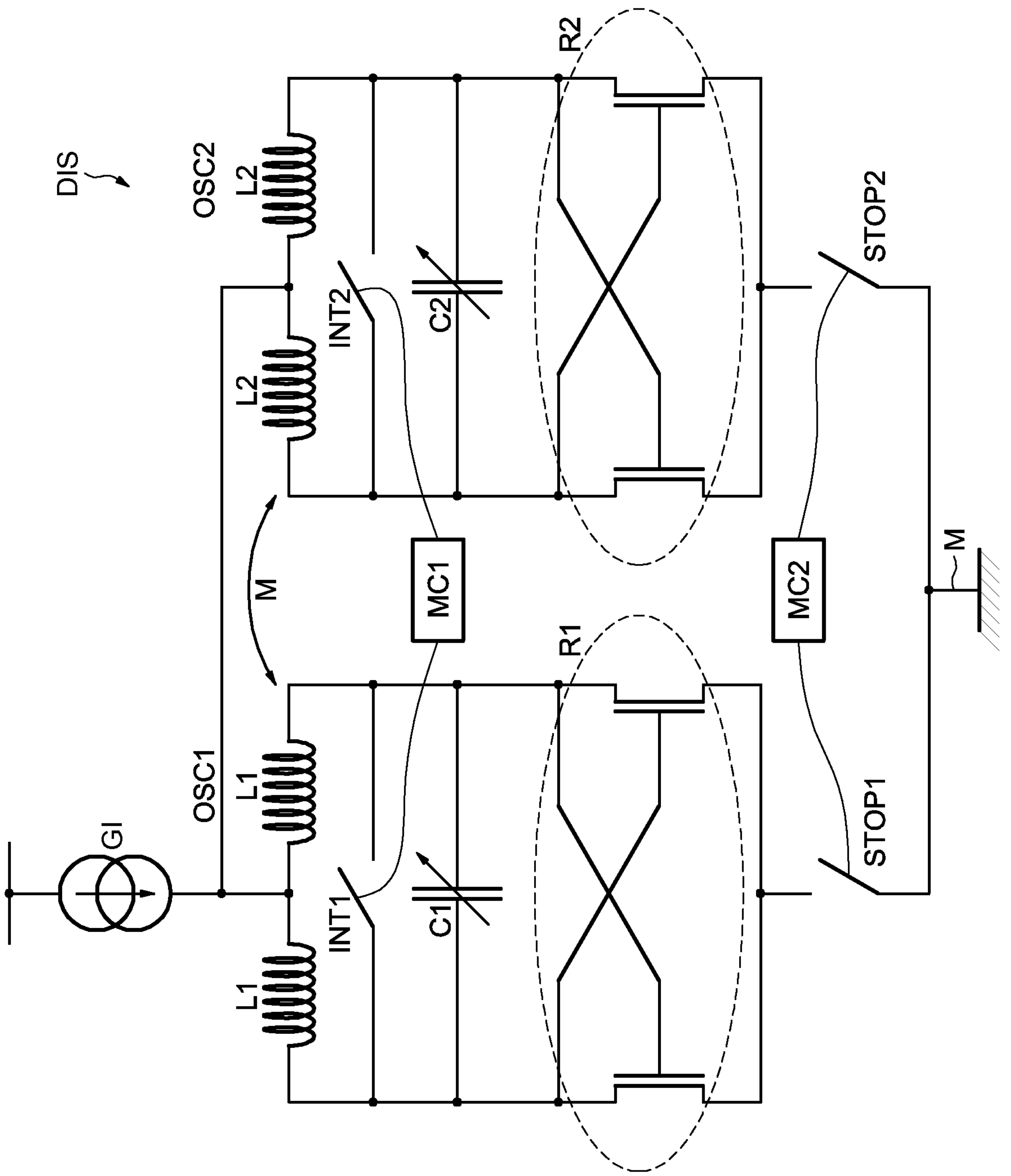


FIG.2


DIS
OSC1
OSC2
GI
L1
L1
L2
L2
INT1
INT2
C1
C2
R1
R2
M
MC1
MC2
STOP1
STOP2
M

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/058353

A. CLASSIFICATION OF SUBJECT MATTER
INV. H03B5/12
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	ZAHRA SAFARIAN ET AL: "A 1.3â 6 GHz triple-mode CMOS VCO using coupled inductors" CUSTOM INTEGRATED CIRCUITS CONFERENCE, 2008. CICC 2008. IEEE, IEEE, PISCATAWAY, NJ, USA, 21 September 2008 (2008-09-21), pages 69-72, XP031361414 ISBN: 978-1-4244-2018-6 * abstract; figure 2a page 70 -----	1-5

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"&" *document member of the same patent family*

Date of the actual completion of the international search	Date of mailing of the international search report
9 September 2010	17/09/2010

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/058353

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	TIEN-LING HSIEH ET AL: "A Reconfigurable Oscillator Topology for Dual-Band Operation" VLSI DESIGN, 2005. 18TH INTERNATIONAL CONFERENCE ON KOLKATA, INDIA 03-07 JAN. 2005, PISCATAWAY, NJ, USA,IEEE LNKD- DOI:10.1109/ICVD.2005.31, 3 January 2005 (2005-01-03), pages 870-873, XP010769953 ISBN: 978-0-7695-2264-7 figures 1, 2 page 1, right-hand column -----	1-5
A	DE 10 2007 023795 A1 (ATMEL DUISBURG GMBH [DE]) 4 December 2008 (2008-12-04) figure 6 * abstract paragraphs [0049] - [0051], [0072] - [0079], [0084] -----	1-5
A	US 2006/033587 A1 (CABANILLAS JOSE [US]) 16 February 2006 (2006-02-16) * abstract; figure 9 -----	1-5

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2010/058353

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US 2006033587 A1	16-02-2006	BR PI0514232 A WO 2006020873 A1	03-06-2008 23-02-2006