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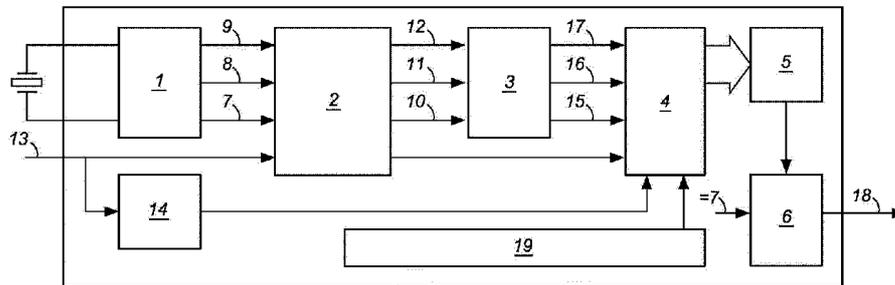
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54 System and method for operating a mechanical resonator in an electronic oscillator.

57 The invention relates to a method for operating a mechanical resonator in an electronic oscillator, comprising determining a state space description of the resonator, in which state variables are the mass, the stiffness or dimensions of components used in the crystal resonator; providing a table with frequency correction factors as a function of a state space of a resonator; finding a frequency correction factor corresponding to the determined state space; and multiplying the output frequency of the resonator with the correction factor, and to an electronic oscillator, comprising a mechanical resonator, wherein an output frequency of the oscillator is multiplied by a frequency correction factor, the frequency correction factor being obtained from determination of the state variables of the resonator, in particular dominant mechanical state variables.



NL C 2011982

Dit octrooi is verleend ongeacht het bijgevoegde resultaat van het onderzoek naar de stand van de techniek en schriftelijke opinie. Het octrooischrift komt overeen met de oorspronkelijk ingediende stukken.

System and method for operating a mechanical resonator in an electronic oscillator

The present invention relates to a system and method for operating a mechanical resonator in an electronic oscillator.

5 Mechanical resonators, such as crystal oscillators, are used as frequency and timing references in electronic equipment. Their frequency stability is of outmost importance. The specification of the frequency stability is usually partitioned over three time ranges, very short term, short term and long term.

Stability over a very short term, usually expressed by time jitter or phase noise, is
10 limited by thermal noise associated with the losses in the crystal and noise added by the electronic oscillation circuit.

The very short term stability of crystal oscillators is known to be extremely good. Crystal resonators have very low losses, that is expressed by their high quality factor (up to 10^6). The noise contribution of the electronics can be kept low through careful
15 design.

Stability over a short time interval is limited by frequency drift due to temperature changes.

A high short term stability of crystal oscillators usually requires special attention. For modern telecommunication purposes the intrinsic short term stability of crystal
20 resonators needs to be improved. Since temperature is the direct cause for short term instability, current methods for improving the short term stability focuses on improvement of their temperature stability.

According to the state of the art, there the following approaches are known.

A first approach is isolation of temperature changes from the crystal, and optimization
25 of the thermal operating point of the crystal. This is the approach taken in so-called ovenized crystal oscillators (OCXOs). Special SC-cut crystals that show zero temperature drift at about 80 degrees Celsius, are placed in an oven that operates at that temperature. The controlled oven isolates the crystal from temperature changes of the environment, up to the temperature at which it is controlled. A disadvantage of ovenized
30 crystals is that they are relatively large, expensive and power consuming.

A second approach is to perform a temperature measurement, calibration and correction. This approach is taken in temperature compensated crystal oscillators (TCXOs) and in microprocessor-controlled crystal oscillators (MCXOs).

In TCXOs the temperature of the crystal is measured with a temperature sensor and the expected change of its frequency of oscillation is compensated by detuning the oscillator with an electrically controlled tuning device such as a VARICAP. The relation between the temperature and the tuning voltage for the VARICAP is determined and stored during calibration and reused during operation.

A disadvantage is that the improvement of the temperature stability is limited because the temperature of the sensor does not perfectly track that of the crystal under all circumstances. Due to factory calibration, the crystal needs to be paired with the electronics.

A third approach, used in MCXOs, is to determine the temperature with the aid of a dual mode oscillator and corrected by cascading it with a microprocessor-controlled frequency synthesizer. In a carefully designed dual-mode oscillator, the so-called beat frequency, which is the frequency difference between a normalized overtone resonance frequency and the fundamental resonance frequency of the crystal, strongly depends on temperature. During calibration this relation is stored and during operation it is used by a microprocessor-controlled frequency synthesizer to correct one of the output frequencies of the dual-mode oscillator. Temperature compensation in MCXOs performs much better than that in TCXOs because the information of the frequency change is derived from the crystal itself, rather than from a temperature sensor.

However, the beat frequency, which is the difference between the fundamental frequency and a normalized overtone frequency and which is used as a measure for temperature in dual-mode oscillators, does not solely depend on temperature; it also depends on mechanical stress in the crystal resonator. Apart from a static component, mechanical stress may vary over time due to different thermal expansion coefficients of the crystal, its connection plates and mounting materials (creepage effects). This causes so-called retrace errors and requires high-performance MCXOs to be equipped with stress-compensated or SC-cut crystals. These crystals are more expensive than popular AT-cut crystals, that in turn are more sensitive to stress. Due to factory calibration, the SC-cut crystal needs to be paired with the electronics.

Stability over a very long period of time is limited by aging. A high-frequency stability over a very long time can be achieved using high-performance packaging techniques that prevent from chemical and physical changes in the operating environment of the crystal.

It is therefore a goal of the present invention, to take away the disadvantages of the prior art, or at least to provide a useful alternative.

The invention therefore comprises a system and method for operating a mechanical resonator in an electronic oscillator, making use of the fact that the resonance modes of mechanical resonators such as piezo crystal resonators, ceramic resonators and MEMS resonators depend on the mass, the stiffness, the dimensions and the mechanical shape of the materials in the resonator.

Most of those are accurately fixed by fabrication, but some of them may depend on the operating conditions of the resonator. For example, in crystal resonators, the dimensions of the crystal depend on temperature and, because to which the crystal is subjected, its stiffness may depend on temperature and life time.

According to the invention, an improved correction of the changes in the output frequency of a crystal oscillator is based upon a so called state space description of the resonator, in which the state variables are the mass, the stiffness and the dimensions of all the components used in the crystal resonator.

Direct measurement of the required these variables, is not required according to the invention. If the temperature drift and the retrace are predominantly affected by the dimensions and the stiffness of the crystal, then direct or indirect measurement of these two state variables already provides an solid base for frequency correction, including retrace.

The invention thus proposes a method initialising a mechanical resonator in an electronic oscillator, comprising:

- a. Determining at least two independent electrically measurable parameters that represent state variables stiffness, mass and/or a dimension of a crystal resonator;
- b. Measuring a resonance mode frequency of a crystal with respect to a known reference signal frequency;
- c. Determining a frequency correction factor that is a ratio of the resonance mode frequency and the reference signal frequency;
- d. Directly or indirectly changing the state variables;
- e. Logging measurement values of the at least two parameters and the corresponding frequency correction factor in a table;
- f. Repeating steps b to e a number of times to populate the table.

During the initialisation phase, a table with frequency correction factors can thus be obtained or be populated by performing measurements before taking the mechanical

resonator actually in use. Once in use, the table may be used as a reference in order to provide a desired output frequency.

Indirect determination of the state variables may mean that the mechanical variables are determined by means of measurement of the electrical resonance parameters, such as
5 the electrical losses, the equivalent inductance and the equivalent capacitance of the resonator. In addition, if a change in the value of the state variables manifests itself differently for different resonance modes of the crystal, such indirect determination may as well be achieved by measuring the output frequencies of a multi-mode crystal oscillator.

10 In fact: over an operation region for which these resonance frequencies form an independent set of variables that maps onto the set of dominant state variables, the correction can be found from a modified state space description of the crystal, in which the mechanical state variables are replaced by the resonant frequencies.

The at least two independent electrically measurable parameters may for instance be
15 selected from the group of: a ratio of a resonance frequency of the crystal with respect to another resonance frequency of the crystal; a power loss in the crystal resonator at one or more of its resonance frequencies; a quality factor of the crystal resonator at one or more resonance frequencies.

In a further embodiment, the method according to the present invention comprises
20 determining the frequency of a base frequency of the resonator in use, and determining at least the ratio between the base frequency and one of the overtones.

Therefore, the frequency or base frequency are determined indirectly, from another electric quantity, like electrical resonance parameters, such as the electrical losses, the equivalent inductance and the equivalent capacitance of the resonator.

25 The invention further relates to a method for operating a mechanical resonator in an electronic oscillator, configured as described above, and comprising the steps of measuring the at least two independent electrically measurable parameters; looking up the correction factor corresponding to the combination of measured parameters and multiplying the output frequency of the resonator with the correction factor.

30 The indirect measurement technique is applied in the current invention. It uses a triple-mode oscillator that produces three output frequencies that are accurately linked to three different resonance frequencies of the crystal. With one of the output frequencies assigned as reference, two frequencies ratios can be measured. These two ratios form set of modified state variables (ϕ_1, ϕ_2) of the crystal resonator.

The multiplication factor $\delta(t)$ for correction of the output frequency can be obtained from these two ratios as:

$$\delta(t) = \begin{bmatrix} \alpha_{10} & \alpha_{11} & \cdots & \alpha_{1n} \\ \alpha_{20} & \alpha_{21} & \cdots & \alpha_{2n} \end{bmatrix} \begin{bmatrix} 1 & 1 \\ \phi_1 & \phi_2 \\ \vdots & \vdots \\ \phi_1^n & \phi_2^n \end{bmatrix}$$

In which n represents the order of nonlinearity in the relation between the correction factor and the change of the state variables.

Current dual-mode oscillators that use the beat frequency as a measure for the temperature correction, use the simplified relation:

$$\delta(t) = \begin{bmatrix} \alpha_{10} & \alpha_{11} & \cdots & \alpha_{1n} \end{bmatrix} \begin{bmatrix} 1 \\ \phi_1 \\ \vdots \\ \phi_1^n \end{bmatrix}$$

In the current invention, two variables are required instead of only one, which makes it possible to compensate for retrace, which is not possible in dual mode oscillators.

The invention further relates to an electronic oscillator that uses a mechanical resonator, in which the output frequency of the oscillator is corrected by cascading it with a digitally controlled frequency synthesizer and in which the frequency correction data is obtained from determination of the state variables of the resonator, in particular the dominant mechanical state variables.

The invention will now be elucidated into more detail with reference to the following figure, wherein figure 1 shows a schematic overview of an electric circuit according to the invention.

Figure 1 shows a simplified functional representation of an electric circuit according to the invention. The circuit comprises a triple-mode crystal oscillator circuit 1, a frequency measurement system 2, a frequency validator 3, a 3D array 4, a data interpolator 5, a fractional synthesizer 6 and a controller 19.

In use, the triple-mode crystal oscillator circuit generates three frequencies 7, 8, 9, that equal three resonance frequencies of the crystal; one of which is selected as base frequency for the fractional synthesizer that generates the output frequency 18.

A high-quality frequency reference signal 13 can be applied to the input of the electronic oscillator. In a self-learning or calibration mode, the frequency measurement system then determines the three different ratios of frequencies 10, 11, 12 generated by

the triple-mode crystal oscillator as well as the frequency correction factor, which is the ratio of the selected base frequency and the reference frequency f_1/f_{ref} .

The frequency correction factor is the factor with which f_{ref} 13 can be obtained from f_1 7. It is stored (appended to existing data) together with a time stamp and a weighting coefficient, determined by the validator 14, at a memory location (x,y) in which x and y uniquely correspond to two ratios of frequencies generated by the triple-mode oscillator, say f_1/f_2 7 / 8 and f_1/f_3 7 / 9.

The memory addresses x and y thus represent the values of the two modified state variables that correspond to the specific operating conditions of the crystal and that change over time with the applied operating conditions.

With slow and rapid changing operating conditions of the crystal (e.g. with changing temperature), frequency correction data with time stamps and weighting coefficients are continuously stored at many different memory locations that map onto the many different operating states of the crystal.

The interpolator 5 estimates the frequency correction data from the data stored in the memory. The fractional synthesizer 6 generates its output frequency from the base frequency and the estimated correction data. The input data for the interpolator is updated with every read cycle. In this way, the output frequency 18 is continuously accurately related to the original frequency reference 13, whether present or not.

One method for estimation of the frequency correction factor could be to calculate a weighted time average of the data stored at a set of memory locations close to those set by the address vector (x,y) and to perform a two-dimensional interpolation of the resulting data set.

Conclusies

1. Werkwijze voor het initialiseren van een mechanische resonator in een elektrische oscillator, omvattende:
 - 5 a. het bepalen van ten minste twee onafhankelijke elektrisch meetbare parameters, welke toestandsvariabelen stijfheid, massa en/of een dimensie van een kristalresonator representeren;
 - b. het meten van een resonantie-modus frequentie van een kristal ten opzichte van een bekende frequentie van een referentiesignaal;
 - 10 c. het bepalen van een frequentie correctiefactor welke een verhouding van de resonantie-modus frequentie en de frequentie van het referentiesignaal is;
 - d. het direct of indirect veranderen van de toestandsvariabelen;
 - e. het registreren van meetwaarden van de ten minste twee parameters en de
15 bijbehorende frequentie correctiefactor in een tabel;
 - f. het herhalen van stappen b tot en met e om de tabel te vullen.

2. Werkwijze volgens conclusie 1, waarbij de ten minste twee onafhankelijke elektrisch meetbare parameters worden geselecteerd uit de groep van:
 - 20 a. Een verhouding van een resonantiefrequentie van het kristal en een andere resonantiefrequentie van het kristal;
 - b. het vermogensverlies in een kristalresonator bij één of meer van zijn resonantiefrequenties
 - c. een kwaliteitsfactor van de kristalresonator bij één of meer
25 resonantiefrequenties;

3. Werkwijze volgens conclusie 1 of 2, waarbij het bepalen van de beschrijving van de toestandsruimte de stappen omvat van:
 - a. het bepalen van de frequenties van een meervoud van
30 resonantiefrequenties van de gebruikte resonator;
 - b. het bepalen van de verhouding van de overtonen;
 - c. het voorzien in een tabel van overtoonverhoudingen en bijbehorende correctiefactoren.

4. Werkwijze voor het bedienen van een mechanische resonator in een elektrische oscillator, ingericht volgens conclusie 1, 2 of 3, omvattende:
 - a. het meten van ten minste twee onafhankelijke elektrisch meetbare parameters;
 - 5 b. het opzoeken van de correctiefactor behorend bij de combinatie van de gemeten parameters;
 - c. het vermenigvuldigen van de uitvoerfrequentie van de resonator met de correctiefactor.

- 10 5. Elektronische oscillator, omvattende een mechanische resonator, waarbij een uitvoerfrequentie van de oscillator is vermenigvuldigd met een frequentie correctiefactor, waarbij de frequentie correctiefactor wordt verkregen volgens één van de conclusies 1-3.

- 15 6. Elektronische oscillator volgens conclusie 5, waarbij de frequentie correctiefactor gegenereerd is door een digitaal gecontroleerde frequentiesynthesizer, in het bijzonder een fractionele synthesizer.

- 20 7. Elektronische oscillator volgens conclusie 5 of 6, omvattende een adresseerbaar geheugen, voor het opslaan van paren verhoudingen van frequenties gegenereerd door de oscillatoren, daarmee vormende veranderde toestandsvariabelen welke overeenkomen met de specifieke gebruikscondities van het kristal.

- 25 8. Elektronische oscillator volgens één van de conclusies 5-7, omvattende een interpolator voor het schatten van de frequentie correctiedata uit de data opgeslagen in het geheugen.

- 30 9. Elektronische oscillator volgens één van de conclusies 5-8, waarbij de fractionele synthesizer is ingericht om zijn uitvoerfrequentie te genereren uit de basisfrequentie en de geschatte correctiedata, en om de invoerdata voor de interpolator bij elke leescyclus bij te werken.

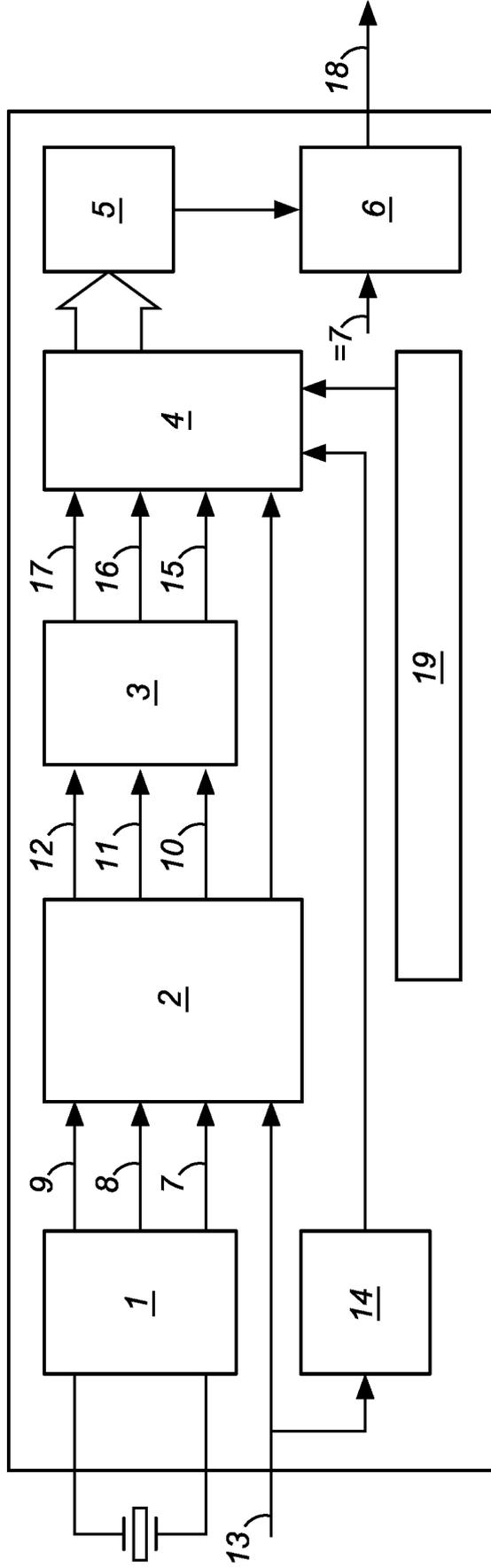


Fig. 1

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE	KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE
	1.881.004 NL
Nederlands aanvraag nr.	Indieningsdatum
2011982	18-12-2013
	Ingeroepen voorrangsdatum
Aanvrager (Naam)	
Frapinventions B.V.	
Datum van het verzoek voor een onderzoek van internationaal type	Door de Instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr.
03-05-2014	SN 61925
I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)	
Volgens de internationale classificatie (IPC)	
H03L1/02	
II. ONDERZOCHE GEBIEDEN VAN DE TECHNIEK	
Onderzochte minimumdocumentatie	
Classificatiesysteem	Classificatiesymbolen
IPC	H03L
Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen	
III. <input type="checkbox"/>	GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES (opmerkingen op aanvullingsblad)
IV. <input type="checkbox"/>	GEBREK AAN EENHEID (opmerkingen op aanvullingsblad)

**ONDERZOEKSRAPPORT BETREFFENDE HET
RESULTAAT VAN HET ONDERZOEK NAAR DE STAND
VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE**

Nummer van het verzoek om een onderzoek naar
de stand van de techniek
NL 2011982

<p>A. CLASSIFICATIE VAN HET ONDERWERP INV. H03L1/02 ADD.</p> <p>Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.</p>											
<p>B. ONDERZOCHETE GEBIEDEN VAN DE TECHNIEK</p> <p>Onderzochte minimum documentatie (classificatie gevolgd door classificatiesymbolen) H03L</p> <p>Onderzochte andere documentatie dan de minimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen</p> <p>Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden) EPO-Internal</p>											
<p>C. VAN BELANG GEACHTE DOCUMENTEN</p> <table border="1"> <thead> <tr> <th>Categorie °</th> <th>Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages</th> <th>Van belang voor conclusie nr.</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>EP 1 898 203 A1 (ULVAC INC [JP]) 12 maart 2008 (2008-03-12) * bladzijde 4, regel 17 - regel 32 * -----</td> <td>1-9</td> </tr> <tr> <td>A</td> <td>US 5 869 763 A (VIG JOHN R [US] ET AL) 9 februari 1999 (1999-02-09) * kolom 4, regel 29 - regel 59 * ----- -/--</td> <td>1-9</td> </tr> </tbody> </table>			Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.	A	EP 1 898 203 A1 (ULVAC INC [JP]) 12 maart 2008 (2008-03-12) * bladzijde 4, regel 17 - regel 32 * -----	1-9	A	US 5 869 763 A (VIG JOHN R [US] ET AL) 9 februari 1999 (1999-02-09) * kolom 4, regel 29 - regel 59 * ----- -/--	1-9
Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.									
A	EP 1 898 203 A1 (ULVAC INC [JP]) 12 maart 2008 (2008-03-12) * bladzijde 4, regel 17 - regel 32 * -----	1-9									
A	US 5 869 763 A (VIG JOHN R [US] ET AL) 9 februari 1999 (1999-02-09) * kolom 4, regel 29 - regel 59 * ----- -/--	1-9									
<p><input checked="" type="checkbox"/> Verdere documenten worden vermeld in het vervolg van vak C. <input checked="" type="checkbox"/> Leden van dezelfde octroofamilie zijn vermeld in een bijlage</p>											
<p>° Speciale categorieën van aangehaalde documenten</p> <p>*A* niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft</p> <p>*D* in de octrooiaanvraag vermeld</p> <p>*E* eerdere octrooi(aanvraag), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven</p> <p>*L* om andere redenen vermelde literatuur</p> <p>*O* niet-schriftelijke stand van de techniek</p> <p>*P* tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur</p> <p>*T* na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvraag, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding</p> <p>*X* de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur</p> <p>*Y* de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht</p> <p>*Z* lid van dezelfde octroofamilie of overeenkomstige octrooipublicatie</p>											
<p>Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid</p> <p>20 augustus 2014</p>		<p>Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type</p>									
<p>Naam en adres van de instantie</p> <p>European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016</p>		<p>De bevoegde ambtenaar</p> <p>Peeters, Mark</p>									

**ONDERZOEKSRAPPORT BETREFFENDE HET
RESULTAAT VAN HET ONDERZOEK NAAR DE STAND
VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE**

Nummer van het verzoek om een onderzoek naar
de stand van de techniek
NL 2011982

C.(Vervolg). VAN BELANG GEACHTE DOCUMENTEN		
Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
A	BENJAMINSON A ET AL: "A MICROCOMPUTER-COMPENSATED CRYSTAL OSCILLATOR USING A DUAL-MODE RESONATOR", PROCEEDINGS OF THE ANNUAL FREQUENCY CONTROL SYMPOSIUM. DENVER, MAY 31 - JUNE 2, 1989; [PROCEEDINGS OF THE ANNUAL FREQUENCY CONTROL SYMPOSIUM], NEW YORK, IEEE, US, deel SYMP. 43, 31 mei 1989 (1989-05-31), bladzijden 20-26, XP000089397, * het gehele document *	1-9
A	----- US 6 420 938 B1 (HOFF LAWRENCE [US] ET AL) 16 juli 2002 (2002-07-16) * kolom 5, regel 12 - bladzijde 8, regel 23 *	1-9
A	----- US 5 604 468 A (GILLIG STEVEN F [US]) 18 februari 1997 (1997-02-18) * het gehele document *	1-9
A	----- US 4 949 055 A (LEITL FRANZ [DE]) 14 augustus 1990 (1990-08-14) * het gehele document *	1-9

**ONDERZOEKSRAPPORT BETREFFENDE HET
RESULTAAT VAN HET ONDERZOEK NAAR DE STAND
VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE**

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar
de stand van de techniek

NL 2011982

In het rapport genoemd octrooigescrift	Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie
EP 1898203	A1	12-03-2008	EP 1898203 A1 12-03-2008
			JP 4669749 B2 13-04-2011
			JP 2007010519 A 18-01-2007
			US 2009038859 A1 12-02-2009
			WO 2007004376 A1 11-01-2007

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			WO 9740580 A1 30-10-1997

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			EP 0323466 A1 12-07-1989
			US 4949055 A 14-08-1990
			WO 8801810 A1 10-03-1988

WRITTEN OPINION

File No. SN61925	Filing date (<i>day/month/year</i>) 18.12.2013	Priority date (<i>day/month/year</i>)	Application No. NL2011982
International Patent Classification (IPC) INV. H03L1/02			
Applicant Frapinventions B.V.			

This opinion contains indications relating to the following items:

- Box No. I Basis of the opinion
- Box No. II Priority
- Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- Box No. IV Lack of unity of invention
- Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- Box No. VI Certain documents cited
- Box No. VII Certain defects in the application
- Box No. VIII Certain observations on the application

	Examiner Peeters, Mark
--	---------------------------

WRITTEN OPINION**Box No. I Basis of this opinion**

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.
2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:
 - a. type of material:
 - a sequence listing
 - table(s) related to the sequence listing
 - b. format of material:
 - on paper
 - in electronic form
 - c. time of filing/furnishing:
 - contained in the application as filed.
 - filed together with the application in electronic form.
 - furnished subsequently for the purposes of search.
3. In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes: Claims	1-9
	No: Claims	
Inventive step	Yes: Claims	1-9
	No: Claims	
Industrial applicability	Yes: Claims	1-9
	No: Claims	

2. Citations and explanations

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following documents:

- D1 EP 1 898 203 A1 (ULVAC INC [JP]) 12 maart 2008 (2008-03-12)
- D2 US 5 869 763 A (VIG JOHN R [US] ET AL) 9 februari 1999 (1999-02-09)
- D3 BENJAMINSON A ET AL: "A MICROCOMPUTER-COMPENSATED CRYSTAL OSCILLATOR USING A DUAL-MODE RESONATOR", PROCEEDINGS OF THE ANNUAL FREQUENCY CONTROL SYMPOSIUM. DENVER, MAY 31 - JUNE 2, 1989; [PROCEEDINGS OF THE ANNUAL FREQUENCY CONTROL SYMPOSIUM], NEW YORK, IEEE, US, deel SYMP. 43, 31 mei 1989 (1989-05-31), bladzijden 20-26, XP000089397,
- D4 US 6 420 938 B1 (HOFF LAWRENCE [US] ET AL) 16 juli 2002 (2002-07-16)
- D5 US 5 604 468 A (GILLIG STEVEN F [US]) 18 februari 1997 (1997-02-18)
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1 INDEPENDENT CLAIM 1

1.1 NOVELTY

D1 is regarded as being the prior art closest to the subject-matter of claim 1, and discloses a method for initialising a mechanical resonator in an electronic oscillator, comprising:

determining one electrically measurable parameter that represents state variable mass (see page 4, lines 17-30) of a crystal resonator,

measuring a resonance mode frequency of a crystal with respect to a known reference frequency signal frequency (see claim 1).

The subject-matter of claim 1 therefore differs from this known method in that it further defines the steps of

- a. Determining at least two independent electrically measurable parameters that represent state variables stiffness, mass and/or a dimension of a crystal resonator;
- b. Measuring a resonance mode frequency of a crystal with respect to a known reference frequency signal frequency;
- c. Determining a frequency correction factor that is a ratio of the resonance mode frequency and the reference signal frequency;
- d. Directly or indirectly changing the state variables;
- e. Logging measurement values of the at least two parameters and the corresponding frequency correction factor in a table;
- f. Repeating steps b to e a number of times to populate the table and is therefore new.

1.2 INVENTIVE STEP

The problem to be solved by the present invention may be regarded as how to provide a method for improving the short term stability of a crystal resonator.

The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step for the following reasons: in the prior art, no reference is made to measuring or using the mechanical state variables of a crystal in order to provide a basis for an action that corrects the short term behaviour of a crystal in a crystal resonator, nor would the relevant prior art lead to said measuring or using the mechanical state variables.

2 INDEPENDENT CLAIM 5

2.1 NOVELTY

D3 is regarded as being the prior art closest to the subject-matter of claim 5, and discloses an electronic oscillator (see figure 3) comprising a mechanical oscillator (OXO, see figure 3), where the output frequency of the oscillator is multiplied by a frequency correction factor.

The subject-matter of claim 5 therefore differs from this known oscillator in that the frequency correction factor is obtained according to one of the claims 1-3 and is therefore new.

2.2 INVENTIVE STEP

The problem to be solved by the present invention according to independent claim 5 may be regarded as how to improve the short term stability of a crystal resonator used in an electronic oscillator.

The solution to this problem proposed in claim 5 of the present application is considered as involving an inventive step because it is similar to the solution presented in claim 1 and is therefore involving an inventive step for the same reason as presented in point 1.2.

3 INDEPENDENT CLAIMS 2-4 AND 6-9

Claims 2-4 and 6-9 are dependent on claims 1 and 5 respectively and as such also meet the requirements of novelty and inventive step.