(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
5 January 2006 (05.01.2006)

PCT

(10) International Publication Number
WO 2006/000621 A1

(51) International Patent Classification^7: **B81B 5/00**, G01P 15/125

(21) International Application Number: PCT/FI2005/000285

(22) International Filing Date: 16 June 2005 (16.06.2005)

(25) Filing Language: Finnish

(26) Publication Language: English

(30) Priority Data:
20040902 29 June 2004 (29.06.2004) FI
20040901 29 June 2004 (29.06.2004) FI

(71) Applicant *(for all designated States except US)*: **VALTION TEKNILLINEN TUTKIMUSKESKUS** [FI/FI]; Vuorimiehentie 5, FI-02150 Espoo (FI).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **SEPPÄ, Heikki** [FI/FI]; Partiotie 26, FI-00370 Helsinki (FI). **KÄRKKÄINEN, Anu** [FI/FI]; Ruonasalmentie 17 C 60, FI-00830 Helsinki (FI). **OJA, Aarne** [FI/FI]; Hempontie 6 B, FI-02660 Espoo (FI).

(74) Agent: SEPPO LAINE OY; Itämerenkatu 3 B, FI-00180 Helsinki (FI).

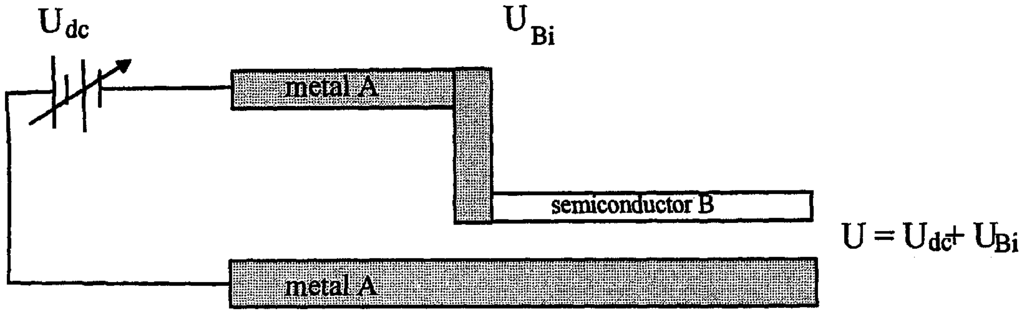
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: ENHANCING STABILITY AND REDUCING TEMPERATURE FACTOR IN A MICROMECHANICAL DEVICE



(57) Abstract: The publication discloses a method for improving stability in a micromechanical sensor, which comprises a part that is arranged to move and a fixed electrode, in such a way that a built-in voltage (U_{bi}) is associated with the sensor. The stability of the sensor is improved by connecting to the sensor a direct-current voltage (U_{dc}) that at least partly compensates for the built-in voltage (U_{bi}) The publication also describes a method for reducing temperature dependence in a micromechanical component, which has a temperature coefficient (β) deriving from the temperature fluctuation of its mechanical properties. In this case, a direct-current voltage (U_{dc}) is connected in series with the built-in voltage (U_{bi}) of the component and the magnitude of the direct-current voltage is selected in such a way that the effect of the temperature fluctuation of the built-in voltage (U_{bi}) at least partly compensates for the effect that the temperature fluctuation of the mechanical properties of the component have on the quantity given by the component.

WO 2006/000621 A1

ENHANCING STABILITY AND REDUCING TEMPERATURE FACTOR IN A MICROMECHANICAL DEVICE

The present invention relates to a method, according to the preamble of Claim 1, for improving stability in a micro-mechanical sensor. The invention also relates to a corresponding micro-mechanical sensor.

A method of this kind can be used in a micro-mechanical sensor that comprises a part that is arranged to move and a fixed electrode. The parts usually contain different kinds of materials, so that a built-in voltage is associated with the construction. The built-in voltage typically varies as a function of time, which causes instability in the sensor.

The invention also relates to a method, according to the preamble of Claim 8, for reducing the temperature dependence of a micro-mechanical component.

A method of this kind can be used in a micro-mechanical component, for example in a sensor, which comprises a part that is arranged to move and a fixed electrode. The part that is arranged to move is usually made from a semiconductor material, for example silicon. Due to the temperature coefficient of the semiconductor material, the mechanical properties of the component vary as a function of temperature, so that the component also gains a significant temperature coefficient.

One object of the invention is to reduce the instability arising from the change in built-in voltage.

A second object of the invention is to reduce the temperature coefficient of the component.

The invention is based on connecting to the component a direct-current voltage that is suitable relative to the built-in voltage.

According to one aspect of the invention, the stability of the sensor is improved by connecting to the sensor a direct-current voltage that at least partly compensates for the built-in voltage. If the absolute value of the sum of the compensating dc voltage and the built-in voltage is less that the absolute value of the built-in voltage, the response of the sensor will be less sensitive to a change in the built-in voltage. If the absolute value of the sum of the dc voltage and the built-in voltage is made very small, the stability of the sensor will improve very significantly.

Micromechanical components usually contain different kinds of materials, so that a built-in voltage is associated with the construction. The built-in voltage typically has a quite significant temperature coefficient. According to another aspect of the invention, a dc voltage is connected in series with the built-in voltage, the magnitude of which dc voltage is selected in such a way that the effect of the temperate change of the built-in voltage at least partly compensates for the effect that the temperature change of the mechanical properties of the component has on the quantity given by the component.

More specifically, one method according to the invention is characterized by what is stated in the characterizing portion of Claim 1. Another method according to the invention is, in turn, characterized by what is stated in the characterizing portion of Claim 8. The sensor according to the invention is, in turn, characterized by what is stated in the characterizing portion of Claim 16.

According to the first aspect of the invention, the instability arising from a change in the built-in voltage can be substantially reduced.

According to the second aspect of the invention, the temperature coefficient of the component can be substantially reduced.

In the following, the invention is examined with the aid of examples and with reference to the accompanying drawings. The examples shown are intended to illustrate the properties of the embodiments of the invention and to investigate the theoretical background to the invention. The examples do not restrict the scope of protection that is defined in the Claims.

Figure 1 shows an arrangement according to one embodiment.

Figure 2 shows an arrangement according to a second embodiment.

Figure 3 shows an arrangement according to a third embodiment.

Figure 4 shows an arrangement according to a fourth embodiment.

Figure 5 shows an arrangement according to a fifth embodiment.

Method for using differential electrodes and the compensation of built-in voltage to improve the stability of micromechanical components.

Typically in micromechanical components the voltage being measured, or the voltage measuring a shift is set between a fixed and a moving plate. It is also possible for there to be fixed electrodes on both sides of a moving plate. Mainly due to differences in the work functions of the materials, a situation arises, in which the voltage over the electrode is determined to some extent from the so-called built-in voltage. This situation is shown in Figure 1. In it, the moving part is made from a semiconducting material and the second electrode from metal. Due to the difference in materials, a potential arises over the air gap, even through voltage is not intentionally created in it. If the capacitance of the component is measured as a function of the external dc voltage, it will be observed that the capacitance reaches its minimum value with a voltage that deviates from zero. This is a typical test that is made on micromechanical components. This basic test can also be exploited in this embodiment.

In amplifiers, it is very typical for the input stage to be formed of two similar transistors, instead of a single transistor. Thus the offset currents, and particularly the drawbacks of their temperature dependences can be significantly reduced. This arrangement is used nearly without exception in operation amplifiers. This embodiment presents, in the case of micromechanical components, a procedure that is analogous to some extent. Figure 2 shows a differential arrangement in the case of the electrodes.

The pull-in point relating to micromechanical components can be exploited, for example, in dc or ac voltage references. The method is based on the fact that, in the case of an ac reference, when using alternating current we can run the component to the so-called pull-in point, or direct-current normal cases we compare the micromechanical capacitance to the reference capacitance and, exploiting the feedback voltage, we hold the system to the pull-in point. In this embodiment, a problem arises from the fact that the built-in voltage sums with the reference voltage and makes the reference unstable. Another problem is the fact that, if either or both of the electrodes becomes charged on account of the dc voltage, the reference voltage will begin to drift.

We will assume that, in the arrangement of Figure 2, the voltage $U + 1/2u$ is set in one of the differential metallized electrodes and the voltage $-U + 1/2u$ is set for the other. In this case, u is a small voltage, which is due to the fact that we cannot invert the voltage U with full precision. In a well-made test arrangement, u/U can be brought to the level 10^{-5} - 10^{-6}. We will assume that the effective pull-in voltage for the construction is U_{pi}. In this case, the pull-in voltage refers to the voltage, which when set in both electrodes causes a pull-in effect. We can now write the equilibrium equation in the form

$$2U_{pi}^2 = \left[\left(U + \frac{1}{2}u\right) - (U_{dc} + U_{bi})\right]^2 + \left[\left(-U + \frac{1}{2}u\right) - (U_{dc} + U_{bi})\right]^2$$

This can be further developed to give

$$2U_{pi}^2 = 2U^2 + \frac{1}{2}u^2 - 2u(U_{dc} + U_{bi}) + 2(U_{dc} + U_{bi})^2$$

We will assume that the voltage U_{dc} is adjusted so that $U_{ac} + U_{bi}$ is as small as possible. We will also assume that the total of the drift of the built-in voltage and U_{dc} is Δu. We can now write the above equation in the form

$$U\left(1 + \frac{1}{8}\frac{u^2}{U^2}\right) = U_{pi}\sqrt{1 + \frac{u\Delta u - \Delta u^2}{U_{pi}^2}}$$

Because both u and $\Delta.u$ are small ($u/U = 10^{-5} \ldots 10^{-6}$ and $\Delta u/U_{pi} = 10^{-4} \ldots 10^{-2}$), the drift of the built-in voltage, or the effect of its temperature coefficient on the reference voltage being measured is nearly non-existent.

As a second example, let use examine an acceleration sensor. We will assume that, in the case of Figure 2, we are measuring capacitance using ac electricity between differential electrodes, or against a moving electrode and either or both fixed electrodes. We can also have a conventional arrangement, which is shown in Figure 3. In that, a ratio of the capacitances is measured and acceleration is deduced therefrom. Let us also assume that in both cases we adjust the dc voltage so that the effective voltage between the moving beam and the measuring electrodes is as small as possible. The voltage required can be determined, for example, by measuring the capacitance as a function of voltage. We can write the total force in the form

$$F = ma + \frac{C_o}{2(l-x)^2}\left[U_{ac} + \left(U_{dc} + U_{pi}\right)\right]^2 = ma + \frac{C_o}{2(l-x)^2}\left[U_{ac}^2 + \left(U_{dc} + U_{pi}\right)^2\right]$$

The right-hand side of the equation allows for the fact that ac voltage is orthogonal relative to dc voltage and thus the mean-time value of these voltages is zero and does not create a force that would give rise to displacement in a micromechanical beam. If we assume that, after compensation for built-in, $U_{dc} + U_{pi} = u$ we obtain

$$F = ma + \frac{C_o}{2(l-x)^2}\left[U_{ac}^2 + u^2\right]$$

We notice that the voltage u creates an acceleration error

$$\Delta a = \frac{C_o}{2m(l-x)^2}u^2$$

If dc-voltage is not used to compensate for the built-in voltage, variation in the built-in voltage (in this case u) would lead to inaccuracy in the measurement

$$\Delta a = \frac{C_o}{2m(l-x)^2}uU_{bi}$$

If we assume that $U_{bi} = 1$ V and the change in it 10 mV, then the differential measurement principle and the compensation of the built-in voltage will improve the measurement inaccuracy arising from the change in the built-in voltage by a factor of 100. We have measured built-in voltages from micromechanical components, which are varied from 0.1 V to as much as 1 V. The effective changes in the voltage created by a possible charging of the temperature time have been in some cases several tens of millivolts. In the case of Figure 3, the situation is the same as that if a dc voltage were to be set for the central moving beam. The change in the so-called built-in voltage can arise from a change in the built-in voltage itself but also charging of the surfaces leads to the same result. It should be noted that the micromechanical systems according to Figure 3 have been manufactured. In this case, the invention does not concern the construction as such, but the fact that we set a voltage in the moving beam, which cancels out the built-in voltage, in order to increase stability. Another possibility is of course to select the materials in such a way that the built-in voltage is as small as possible, without a compensating voltage.

The embodiment described above presents a method, in which the use of a differential MEMS construction and compensation of the built-in voltage can substantially improve the stability of micromechanical components. The method is extremely valuable in all components that demand great accuracy, such as an ac or dc reference, an ac-dc rectifier, a microwave power sensor, an angular velocity sensor, etc.

Thus the above presents a method for improving stability in a micromechanical sensor, which comprises a part that is arranged to move and a fixed electrode, in such a way that a built-in voltage U_{bi} is associated with the sensor. The stability of the sensor is improved by connecting a dc voltage U_{dc} to the sensor, which will at least partly compensate for the built-in voltage U_{bi}.

In one embodiment, the sum of the dc voltage U_{dc} and the built-in voltage U_{bi} is controlled towards zero. The control can be implemented, for example, with the aid of a suitable electronic circuit.

When controlling the sum of the dc voltage U_{dc} and the built-in voltage U_{bi}, the aim can be, for example, for the absolute value of the dc voltage U_{dc} and the built-in voltage U_{bi}, to be at most 10 mV. This will already achieve good stability in many applications. In more accurate applications, it is of course possible to aim at keeping the absolute value of the sum lower, for example, at a value of at most 5 mV or 1mV. In some other applications on the other hand, it is equally possible to accept greater variation and the absolute value of the sum can be kept, for example, at a value of at most 50 mV or even 100 mV.

In one embodiment, the value of the built-in voltage U_{bi} is measured and the magnitude of the dc voltage U_{dc} is set in such a way that the absolute value of the sum of the dc voltage U_{dc} and the built-in voltage U_{bi} is at most 10 % and preferably at most 4 % of the absolute value of the pull-in voltage of the component.

The dc voltage U_{dc} is connected, for example, to the part of the sensor that is arranged to move, which can be, for example, of a semiconducting material, in which case the fixed electrode can comprise a metal surface.

The embodiments described above can be used, for example, in a voltage reference, in which the reference voltage U is connected to the sensor. This makes it possible to use a fixed electrode divided into a first and a second part, in which case the reference voltage U is connected to the first part of the fixed electrode and the inverted reference voltage $-U$ is connected to the second part of the fixed electrode.

In a sensor embodiment, a micromechanical sensor is implemented, which comprises a part arranged to move and a fixed electrode. Such a sensor can be manufactured using a suitable known method for manufacturing micromechanical sensors. The sensor manufactured will typically have a built-in voltage U_{bi}. According to the embodiment, a direct-current voltage U_{dc} is connected to the sensor, in order to at least partly compensate for the built-in voltage U_{bi}.

In one embodiment, the fixed electrode of the sensor comprises first and a second part, as well as means for leading the reference voltage U to the first part and means for leading the inverted reference voltage *-U* to the second part. The means for leading the reference voltage *U* to the first part comprise a voltage source and a conductor channel from the voltage source to the first part. The means for leading the inverted reference voltage *-U* to the second part comprise the voltage source referred to above, an inverter, and a conductor channel from the voltage source to the inverter and a conductor channel from the inverter to the second part. It is also possible to use two separate voltage sources, which produce with a high accuracy voltage with the same absolute value.

In one embodiment, the first and second part of the fixed electrode of the sensor are located on the same side of the part that is arranged to move.

Use of built-in voltage and its temperature dependence in the temperature compensation of micromechanical components.

The temperature coefficient or mechanical stresses of a micromechanical spring often result in micromechanical components having largish temperature coefficients. This is particularly problematic in precision components based on micromechanics. In micromechanical components, there is typically an electrical field between the moving silicon beam and the metal electrode. Though both electrodes can be metal, the spring is often made from silicon. Nearly always there is more than one type of conductive material in the construction. A voltage arises between of the conductors, due to the fact that they have different work functions. In particular, the work function of semiconductors differs significantly from the work function of metals. Generally this is not a problem, because in closed conductive circuits the voltage ‘short-circuits’ and does not interfere with measurements. The phenomenon usually only appears, if the contacts differ in temperature, in which case the phenomenon will appear as a so-called thermo-voltage.

Let us consider the simplified construction according to Figure 4, in which the conductor A is formed of metal and the second electrode and spring are formed of a semiconductor B. Because the work function of the metal A differs from the work function of the semiconductor B, and because in the semiconductor the work function depends greatly on the temperature, the effective voltage between the electrodes can be written in the form

$$U = U_{ac} + U_{dc} + U_{bi} + \alpha T$$

in which U_{ac} and U_{dc} represent external ac and dc voltage sources, U_{bi} is the built-in voltage created by the metal A and the semiconductor B, and α is its temperature coefficient. Let us assume that we are measuring, for example, a displacement caused by acceleration or pressure. We can write the equilibrium of forces in the form

$$kx(1+\beta T) = F + \frac{C}{2(l-x)}\left[(U_{dc}+U_{bi})^2 + 2(U_{dc}+U_{bi})\alpha T + U_{ac}^2\right]$$

in which F is the 'mechanical' force acting on the component, C is the capacitance of the moving part, l is the air gap without external forces, x is the displacement of the air gap, and β depicts, for example, the temperature coefficient of the elastic constant of silicon. From this equation we then obtain

$$x = \frac{1}{k}\left[F(1-\beta T) + \frac{C}{2(l-x)}\left[(U_{dc}+U_{bi})^2 + U_{ac}^2\right] + \frac{CT}{2(l-x)}\left(2\alpha(U_{dc}+U_{bi}) - \beta\left[(U_{dc}+U_{bi})^2 + U_{ac}^2\right]\right)\right]$$

If we assume for simplicity that the ac voltage is small, we obtain

$$x = \frac{1}{k}\left[F(1-\beta T) + \frac{C}{2(l-x)}(U_{dc}+U_{bi})^2 + \frac{CT(U_{dc}+U_{bi})}{2(l-x)}\left(2\alpha - \beta(U_{dc}+U_{bi})\right)\right]$$

i.e. the temperature coefficient of the offset is zero, if

$$U_{dc} = \frac{1}{\beta}(2\alpha - \beta U_{bi}) \text{ or } U_{dc} = -\beta U_{bi}$$

This means that in principle a dc voltage U_{dc} always exists, so that the temperature coefficient of the offset is cancelled out. In this example, a temperature dependence remains in the coefficient of the force-motion conversion, but in most applications this is acceptable. The necessary dc voltage, together with the built-in voltage cannot, of course, be greater than the so-called pull-in voltage (U_{pi}) of a vacuum, i.e. $|U_{dc} + U_{bi}| < U_{pi}$. The use of the method thus requires the temperature coefficient of the built-in voltage to be sufficiently great.

Let us assume that we adjust the ac voltage in such a way that we achieve the pull-in voltage. If we use current to control the micromechanical component, the voltage will reach the pull-in voltage at a specific amplitude of alternating current. If the current continues to increase, the voltage will decrease. This point can be used as the reference of the ac voltage. In the ac reference, the pull-in point can also be achieved by combining the ac current run and the dc voltage over the component. This can be written in the form

$$U_{pi}^2(1+2\beta'T) = U_{ac}^2 + (U_{dc}+U_{bi})^2 + 2\alpha T(U_{dc}+U_{bi})$$

in which β' now depicts the change in the pull-in voltage due to the elastic constant (in a good component about 30 ppm/C). The stabilized ac voltage can be written in the form

$$U_{ac}^2 = U_{pi}^2 - (U_{dc}+U_{bi})^2 + 2\left[\beta' U_{pi}^2 - \alpha(U_{dc}+U_{bi})\right]T$$

We note that, if

$$U_{dc} = 2\frac{\beta'}{\alpha}U_{pi}^2 - U_{bi}$$

then the temperature coefficient of the reference voltage will be zero. This naturally requires the necessary dc voltage to remain less than the pull-in voltage. In addition, it should be noted that the stability of the ac voltage will depend on the stability of the dc voltage.

The dc reference voltage can be made using the arrangement according to Figure 4. In it, a differential procedure is used, in which a positive reference voltage is brought to electrode A and a negative reference voltage with an equally great absolute value is brought to electrode B. The voltage in the moving beam consists of a dc voltage source and the built-in voltage. The system will reach the pull-in point, if the sum of the forces corresponds to the force created by the pull-in voltage. We can write the equation

$$2U_{pi}^2(1+2\beta' T)=((U_{dc}+u)-(U_{dc}+U_{bi}+\alpha T))^2+(-U_{dc}-(U_{dc}+U_{bi}+\alpha T))^2$$

$$U_{pi}^2(1+2\beta')=U_{ref}^2+uU_{ref}+(U_{dc}+U_{bi})^2+2\alpha T(U_{dc}+U_{bi})$$

and then obtain from it

$$U_{ref}^2+uU_{ref}=U_{pi}^2-(U_{dc}+U_{bi})^2+2\left[\beta' U_{pi}^2-\alpha(U_{dc}+U_{bi})\right]T$$

In this case too, the temperature coefficient of the dc reference voltage is zero, if

$$U_{dc}=\frac{\beta'}{\alpha}U_{pi}^2-U_{bi}$$

The temperature coefficient of the built-in voltage can be used to compensate for the temperature coefficient of the micromechanical sensor or reference component. The method can be used in pressure sensors, oscillators, possibly in angular-velocity sensors, in dc and ac voltage sources, etc. Because the built-in voltage forms in the components themselves, it compensates well for the temperature fluctuations arising in the components. Because there is a large temperature coefficient of the work function in semiconductors, it is probably easier to use them to manufacture components, in which the temperature coefficient can be compensated using the temperature coefficient of the built-in voltage. In measurements we have observed that the temperature coefficient of the built-in voltage is in the order of 0.3 - 0.5 mV/C. For example, the temperature coefficient of a single-crystal silicon spring is in the order of 50 ppm/C, so that it can be compensated using the temperature coefficient of the built-in voltage. Of course, if the temperature coefficient is large, direct compensation will not be possible.

The aforementioned use of the built-in voltage compensates the temperature coefficient of a micromechanical component directly. The temperature coefficient of the built-in voltage can also be used as a temperature gauge, in such way that a separate component is made in the micromechanical component, through the change in the capacitance or pull-in voltage of which the temperature of the component is measured. This information can be used, for example, to temperature compensate an angular-velocity sensor in the same silicon base. This is a kind of indirect way to exploit the temperature coefficients of the work functions as a temperature gauge.

The temperature dependence of a micromechanical component, which comprises a part that is arranged to move and a fixed electrode as well as the temperature coefficient β that derives from the temperature fluctuation of the mechanical properties of the component, can thus be reduced using a method, in which a dc voltage U_{dc} is connected in series with the built-in voltage U_{bi} of the component. The magnitude of the dc voltage is then selected in such a way that the effect of the temperature fluctuation of the built-in voltage U_{bi} at least partly compensates for the effect that the temperature fluctuation of the mechanical properties of the component has on the quantity given by the component.

In one embodiment, the value of the dc voltage U_{dc} is selected in such a way that it differs by at most 10 % from the target value that is obtained from the equation

$$U_{dc}^{opt} = \frac{1}{\beta}(2\alpha - \beta U_{bi})$$

in which β is the temperature coefficient derived from the temperature fluctuation of the mechanical properties of the component, α is the temperature coefficient of the built-in voltage, and U_{bi} is the magnitude of the built-in voltage. In more accurate applications, the value of the dc voltage can be selected, for example, in such a way that the deviation is at most 5 % and in very accurate applications in such a way that the deviation is at most 1 %. If, on the other hand, such great accuracy is not need in the application, the deviation can be permitted to be greater, for example, at most 20 % or 30 %.

The selection of the dc voltage can also be implemented in such a way that the value of the dc voltage is controlled the whole time towards the target value given above. The control can be implemented, for example, using a suitable electronic circuit.

One further possible control criterion for the value of the dc voltage U_{dc} is obtained from the sensor's pull-in voltage. In that case, the dc voltage U_{dc} is limited in such a way that the absolute value of the sum of the dc voltage U_{dc} and the built-in voltage U_{bi} is always smaller than the sensor's pull-in voltage U_{pi}.

The dc voltage U_{dc} can be connected, for example, to the part of the sensor that is arranged to move, which is typically of a semiconductor material while the fixed electrode comprises a metal surface.

The embodiments described above can also be used in a voltage reference, in which a reference voltage U is connected to the sensor. In that case, a fixed electrode divided into a first and a second part is used and the reference voltage U is connected to the first part of the fixed electrode and the inverted reference voltage $-U$ is connected to the second part of the fixed electrode. Further, in one embodiment the first and second part of the fixed electrode are located on the same side of the part that is arranged to move.

Claims:

1. Method for improving stability in a micromechanical sensor, which comprises a part that is arranged to move and a fixed electrode, in such a way that a built-in voltage (U_{bi}) is associated with the sensor, characterized in that the stability of the sensor is improved by connecting to the sensor a direct-current voltage (U_{dc}) that at least partly compensates for the built-in voltage (U_{bi}).

2. Method according to Claim 1, characterized in that the sum of the direct-current voltage (U_{dc}) and the built-in voltage (U_{bi}) is controlled towards zero.

3. Method according to Claim 1 or 2, characterized in that the absolute value of the sum of the direct-current voltage (U_{dc}) and the built-in voltage (U_{bi}) is at most 10 mV.

4. Method according to Claim 1 or 2, characterized in that the value of the built-in voltage (U_{bi}) is measured and the magnitude of the direct-current voltage (U_{dc}) is set in such a way that the absolute value of the sum of the direct-current voltage (U_{dc}) and the built-in voltage (U_{bi}) is at most 10 % and preferably at most 4 % of the absolute value of the pull-in voltage of the component.

5. Method according to any of Claims 1 - 4, characterized in that the direct-current voltage (U_{dc}) is connected to the part of the sensor that is arranged to move.

6. Method according to any of Claims 1 - 5, characterized in that the part of the sensor that is arranged to move is of a semiconductor material while the fixed electrode comprises a metal surface.

7. Method according to any of Claims 1 - 6 for use in a voltage reference, in which a reference voltage (U) is connected to the sensor, characterized in that a fixed electrode divided in a first part and a second part is used and the reference voltage (U) is connected to the first part of the fixed electrode and the inverted reference voltage ($-U$) is connected to the second part of the fixed electrode.

8. Method for reducing the temperature dependence of a micromechanical component, which component comprises a part that is arranged to move and a fixed electrode and which component has a temperature coefficient (β) derived from the temperature fluctuation of its mechanical properties, characterized in that a direct-current voltage (U_{dc}) is connected to the component in series with the built-in voltage (U_{bi}) of the component and the magnitude of the direct-current voltage is selected in such a way that the effect of the temperature fluctuation of the built-in voltage (U_{bi}) at least partly compensates for the effect that the temperature fluctuation of the mechanical properties of the component has on the quantity given by the component.

9. Method according to Claim 8, characterized in that the value of the direct-current voltage (U_{dc}) differs at most by 10 % from the target value that is obtained from the equation

$$U_{dc}^{opt} = \frac{1}{\beta}(2\alpha - \beta U_{bi})$$

in which β is the temperature coefficient derived from the temperature fluctuation of the mechanical properties of the component, α is the temperature coefficient of the built-in voltage, and U_{bi} is the magnitude of the built-in voltage.

10. Method according to Claim 8 or 9, characterized in that the value of the direct-current voltage (U_{dc}) is controlled towards the target value that is obtained from the equation

$$U_{dc}^{opt} = \frac{1}{\beta}(2\alpha - \beta U_{bi})$$

in which β is the temperature coefficient derived from the temperature fluctuation of the mechanical properties of the component, α is the temperature coefficient of the built-in voltage, and U_{bi} is the magnitude of the built-in voltage.

11. Method according to Claim 10, characterized in that, when controlling the value of the direct-current voltage (U_{dc}), the direct-current voltage (U_{dc}) is limited in such a way that the absolute value of the sum of the direct-current voltage (U_{dc}) and the built-in voltage (U_{bi}) is always less than the pull-in voltage (U_{pi}) of the sensor.

12. Method according to any of Claims 8 -11, characterized in that the direct-current voltage (U_{dc}) is connected to the part of the sensor that is arranged to move.

13. Method according to any of Claims 8 - 12, characterized in that the part of the sensor that is arranged to move is of a semiconductor material while the fixed electrode comprises a metal surface.

14. Method according to any of Claims 8 - 13 for use in a voltage reference, in which a reference voltage (U) is connected to the sensor, characterized in that a fixed electrode divided into a first part and a second part is used and the reference voltage (U) is connected to the first part of the electrode and the inverted reference voltage ($-U$) is connected to the second part of the fixed electrode.

15. Method according to Claim 14, characterized in that the first and second parts of the fixed electrode are located on the same side of the part that is arranged to move.

16. Micromechanical sensor, which comprises a part that is arranged to move and a fixed electrode, and which sensor has a built-in voltage (U_{bi}), characterized in that a direct-current voltage (U_{dc}) is connected to the sensor, in order to at least partly compensate the built-in voltage (U_{bi}).

17. Sensor according to Claim 16, characterized in that the fixed electrode comprises a first and a second part and means for conducting the reference voltage (U) to the first part and means for conducting the inverted reference voltage ($-U$) to the second part.

18. Sensor according to Claim 17, characterized in that the first and second parts of the fixed electrode are located on the same side of the part that is arranged to move.

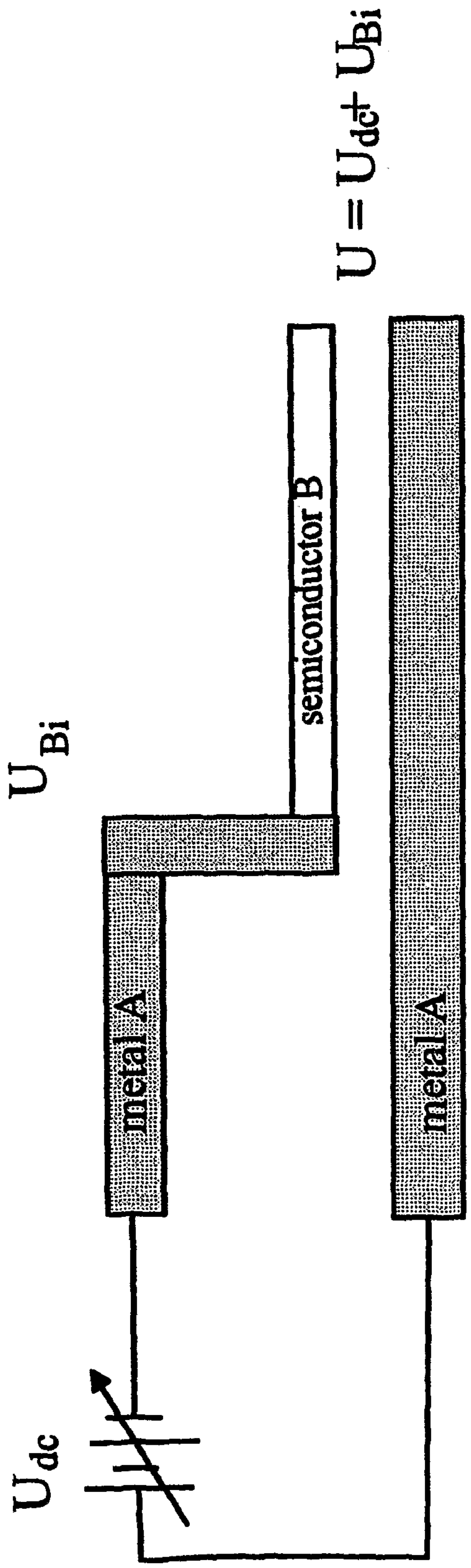


Figure 1:

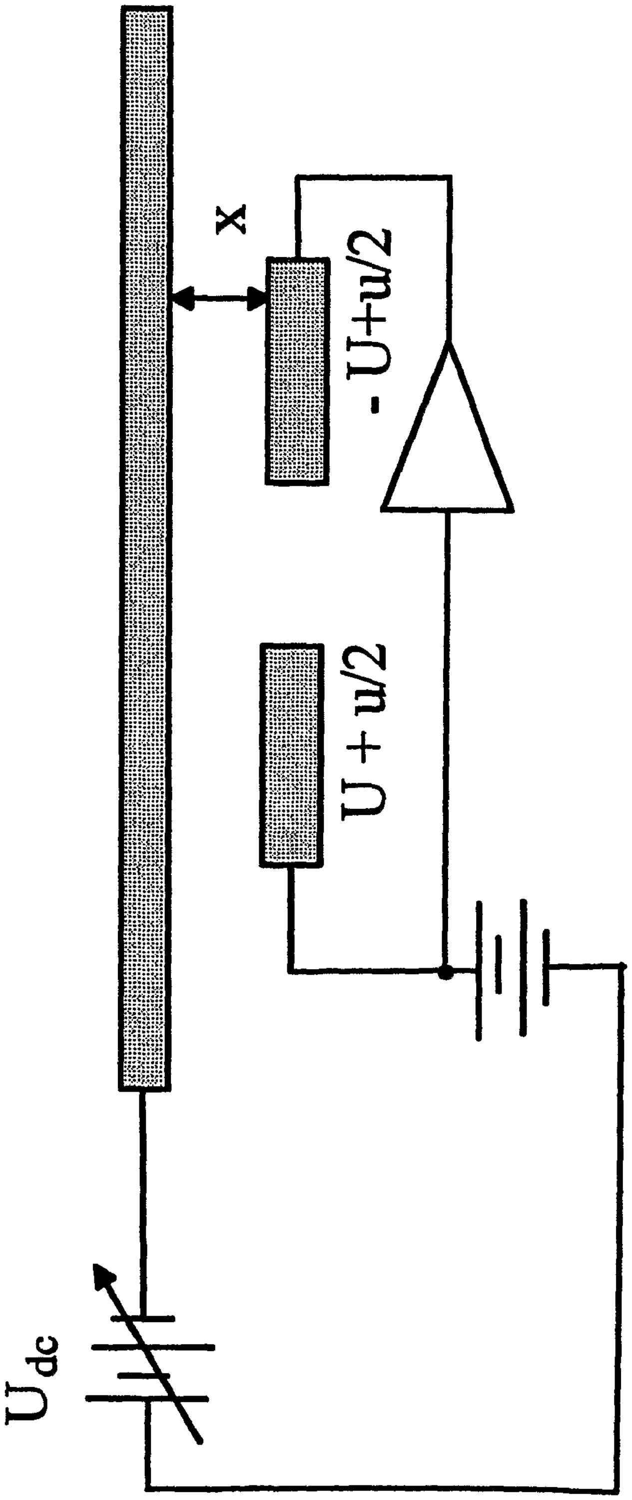


Figure 2:

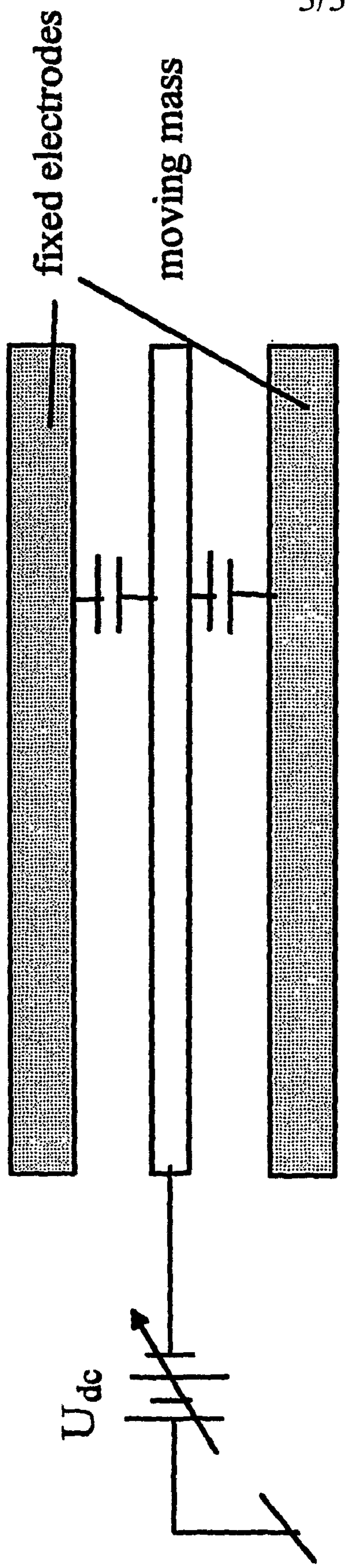


Figure 3:

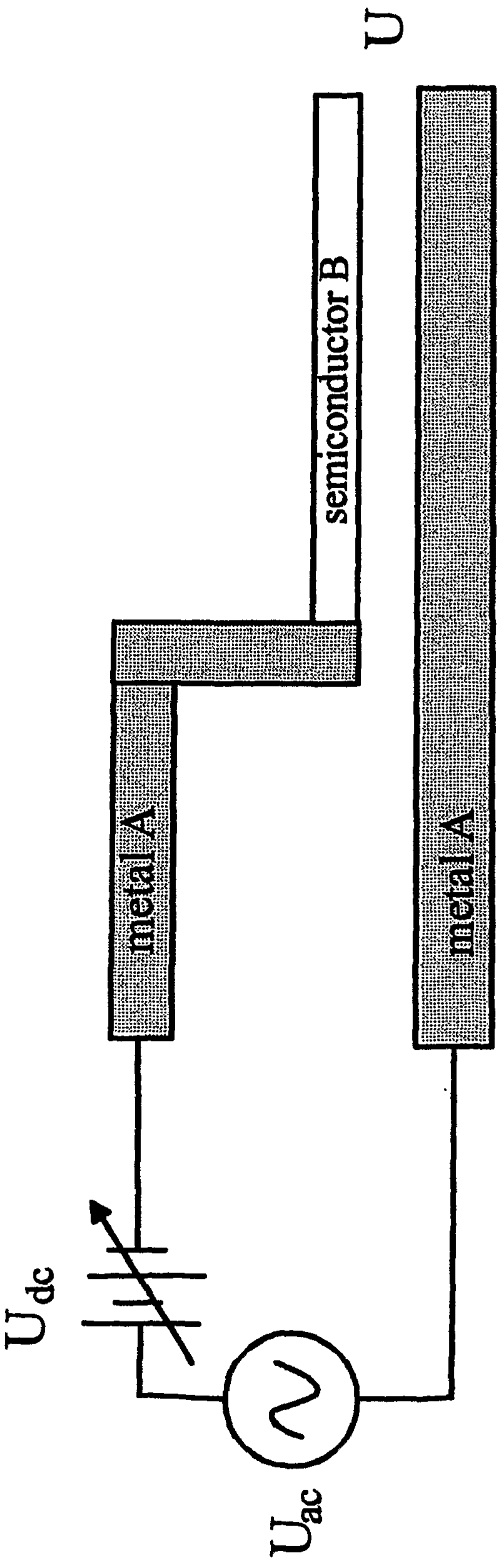


Figure 4:

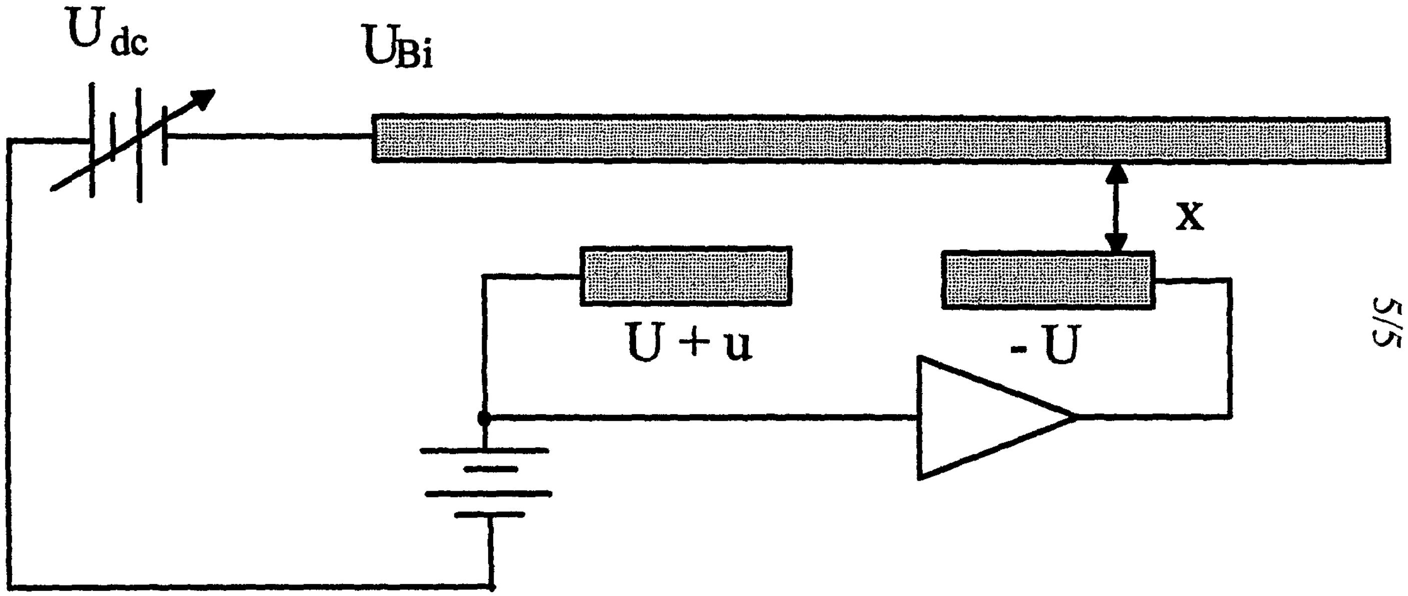


Figure 5:

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 2005/000285

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B81B 5/00, G01P 15/125

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)

IPC7: B81B, G01P

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

SE,DK,FI,NO classes as above

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

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6559661 B1 (MUCHOW, J. ET AL), 6 May 2003 (06.05.2003), column 1, line 43 - column 5, line 55 --	1-18
A	US 6722203 B1 (EVANS, J.R. ET AL), 20 April 2004 (20.04.2004), column 4, line 54 - column 5, line 30; column 10, line 7 - column 13, line 22 -- --------	1-18

☐ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

* Special categories of cited documents:

"A"	document defining the general state of the art which is not considered to be of particular relevance
"E"	earlier application or patent but published on or after the international filing date
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O"	document referring to an oral disclosure, use, exhibition or other means
"P"	document published prior to the international filing date but later than the priority date claimed
"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X"	document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y"	document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&"	document member of the same patent family

Date of the actual completion of the international search
19 Sept 2005

Date of mailing of the international search report
22 -09- 2005

Name and mailing address of the ISA/
Swedish Patent Office
Box 5055, S-102 42 STOCKHOLM
Facsimile No. +46 8 666 02 86

Authorized officer
Fredrik Wahlin /OGU
Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

31/08/2005

International application No.

PCT/FI 2005/000285

US	6559661	B1	06/05/2003	DE	19848362	A	27/04/2000
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				EP	1123492	A,B	16/08/2001
				JP	2002527767	T	27/08/2002
				WO	0023777	A	27/04/2000
US	6722203	B1	20/04/2004	NONE			