(45) Date of publication and mention of the grant of the patent:
23.05.2012 Bulletin 2012/21

(21) Application number: 01972510.0

(22) Date of filing: 26.09.2001

(51) Int Cl.:
H03B 5/36 (2006.01)

(86) International application number:
PCT/JP2001/008393

(87) International publication number:

(54) OSCILLATION CIRCUIT, ELECTRONIC CIRCUIT, AND SEMICONDUCTOR DEVICE, CLOCK, AND ELECTRONIC APPARATUS WHICH COMPRISE THESE CIRCUITS
OSZILLATIONSSCHALTUNG, ELEKTRONISCHE SCHALTUNG UND HALBLEITERBAUELEMENT, ZEITGEBER UND ELEKTRONISCHE VORRICHTUNG MIT DIESEN SCHALTUNGEN
CIRCUIT D’OSCILLATION, CIRCUIT ELECTRONIQUE ET DISPOSITIF SEMI-CONDUCTEUR, HORLOGE, ET APPAREIL ELECTRONIQUE COMPRENANT CES CIRCUITS

(84) Designated Contracting States:
CH DE FR GB LI


(43) Date of publication of application:

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(56) References cited:
JP-A- 50 098 263

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The present invention relates to an oscillation circuit and an electronic circuit, and a semiconductor device, a timepiece and electronic equipment provided with the same.

The oscillation circuit used in a portable wristwatch or electronic equipment often has a configuration such that a principal circuit portion thereof that is formed on a semiconductor substrate is connected by input-output terminals to a crystal oscillator provided at a separate location on that semiconductor substrate. For that reason, an electrostatic protection circuit is provided on the input-output terminal side of that principal circuit portion, to protect that principal circuit portion from any surge voltage intruding from the exterior through those input-output terminals.

However, in such a conventional circuit, the power source of the oscillation circuit drive is utilized for bypassing surge voltages of the electrostatic protection circuit, so that if there should be a change in the power-supply voltage of the oscillation circuit for some reason, that would cause a change in the parasitic capacitance of that electrostatic protection circuit and, as a result, that would raise a problem in that the oscillation frequency of the oscillation circuit will change.

An objective of the present invention is to provide an oscillation circuit and an electronic circuit which enable protection of the principal circuit portions thereof from any surge voltage that intrudes from the exterior through input-output terminals, and which can oscillate at a stable frequency without being affected by changes in the power-supply voltage of the oscillation circuit, together with a semiconductor device, a timepiece and electronic equipment that are provided with the oscillation circuit and the electronic circuit.

With electronic circuitry, it is common to provide various different constant voltages separate from the power source of the oscillation circuit, and it is also possible to generate a power-supply voltage for the oscillation circuit and another constant voltage that is not readily affected by changes in that power-supply voltage.

An oscillation circuit in accordance with the present invention utilizes an electrostatic protection circuit of a configuration such that it is connected to a constant-voltage side which is not greatly affected by changes in that power-supply voltage, instead of being connected to the power-source side of the oscillation circuit. Since this means that there is no change in the constant bypass voltage connected to the electrostatic protection circuit even if the voltage of the power source for the oscillation circuit changes, it is possible to effectively suppress any change in the parasitic capacitance of the semiconductor rectifier element that configures the electrostatic protection circuit. In one embodiment, a discharging semiconductor rectifier element for discharging an electrostatic voltage of a first polarity that intrudes into the signal path to a side of a constant bypass voltage through the first semiconductor rectifier element, is provided between an output of the constant voltage supply circuit which supplies the constant bypass voltage and the reference potential of said constant-voltage generating means.

To his objective is achieved by an oscillation circuit as claimed in claim 1. Preferred embodiments of the invention are defined in the dependent claims.

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In another embodiment, when it is assumed that the power-supply voltage is $V_{SS}$, the forward-direction on-voltage of the semiconductor rectifier element is $V_{Fon}$, and the potential difference between the signal path and the power-supply voltage line when a leakage current is generated is $V_{RC}$, the constant bypass voltage $V_{reg}$ may be set in
such a manner that the following inequality is satisfied, within a range of expected operating voltages of the power-supply voltage $|V_{SS}|$: $|V_{reg}| > |V_{SS}| - V_R - V_{Fon}$.

[0011] The present invention therefore makes it possible to provide an oscillation circuit that has no change in oscillation frequency, even if the power-supply voltage of the oscillation circuit should change.

[0012] In this case, components such as diodes or bipolar transistors can be used as the first and second semiconductor rectifier elements of the electrostatic protection circuit, as necessary.

[0013] In particular, the parasitic capacitance of the third semiconductor rectifier element could be set to a value of an order of magnitude that can be ignored in comparison with the parasitic capacitance of the first semiconductor rectifier element.

[0014] This configuration ensures that, even if the parasitic capacitance of the third semiconductor rectifier element has been changed by a change in the main power-supply voltage, this will not have any substantial effect, making it possible to provide an oscillation output at a stable oscillation frequency.

[0015] In accordance with the present invention, the parasitic capacitance of each of the above semiconductor rectifier elements could be used as either a part or the entirety of a phase-compensation capacitor.

[0016] This configuration makes it possible to omit either part or the entirety of such a phase-compensation capacitor, and also makes it possible to increase the degree of integration of the overall circuit.

[0017] Electronic equipment may be configured to comprise an oscillation circuit, a drive circuit which drives a driven section, based on an output of the oscillation circuit, and the driven section.

[0018] This makes it possible to implement electronic equipment that can generate an accurate oscillation output that is not affected by any changes in the power-supply voltage of the oscillation circuit, to cause the operation of the parts of the circuit.

[0019] In particular, a timepiece or electronic equipment that uses an oscillation circuit or electronic circuit in accordance with the present invention is extremely suitable as a portable timepiece or other item of electronic equipment that uses an exchangeable battery or a rechargeable battery as a main power source.

**Brief Description of the Drawings**

[0020] Fig. 1 is a block diagram of an example of an electric circuit for a wristwatch, to which the present invention is applied.

Fig. 2 is a block diagram of the timepiece circuit portion of the electronic circuit of Fig. 1

Fig. 3 is a block diagram of another embodiment of the timepiece circuit portion.

Fig. 4 is a block diagram of a further embodiment of the timepiece circuit portion.

Fig. 5 is illustrative of the state of voltage variations in two different power sources used by the circuit of this embodiment of the present invention.

Fig. 6A is an equivalent circuit diagram of the crystal oscillation circuit of Fig. 2. Fig. 6B is illustrative of the crystal oscillator. Fig. 6C is an equivalent circuit diagram of the crystal oscillator. Fig. 6D is the equivalent circuit of Fig. 6A that has been formed from consideration of the equivalent circuit of the crystal oscillator.

Fig. 7 is illustrative of another electrostatic protection circuit.

Fig. 8 is illustrative of an electrostatic protection circuit used in the prior art.

Fig. 9 is an equivalent circuit of the electrostatic protection circuit of Fig. 7.

Fig. 10 is illustrative of an electrostatic protection circuit fabricated by using other types of semiconductor elements.

Fig. 11 is illustrative of the layout of a CMOS-IC that forms essential components of a crystal oscillator and an oscillation circuit on a substrate.

Fig. 12 is an equivalent circuit of a case in which a leakage current is generated between the signal path of the oscillation circuit and the power-supply voltage line.

Fig. 13 is illustrative of the temperature characteristics of the oscillation-stopping voltage and the constant voltage for driving the oscillation, within the guaranteed operating temperature range of the oscillation circuit.

Fig. 14 is a schematic illustrative view of the constant voltage generation circuit for driving a temperature sensor.

Fig. 15 shows an embodiment of the invention that is illustrative of the discharge pathways when an electrostatic voltage of a negative polarity is applied.

**BEST MODE FOR CARRYING OUT THE INVENTION**

[0021] Preferred embodiments of the present invention and examples which are useful for understanding the invention are described below with reference to examples in which the present invention is applied to a wristwatch having an analog display.
(1) Overall Configuration

[0022] An example of an electronic circuit used in this wristwatch is shown in Fig. 1.

[0023] This wristwatch has an internal power generation mechanism that is not shown in this figure. When the user moves the arm on which the wristwatch is placed, a rotating weight of a power generation mechanism rotates, a power-generating rotor is made to rotate at high speed by the movement energy generated thereby, and an AC voltage is output from a power-generating coil 10 provided on a power-generating stage side.

[0024] This AC voltage is rectified by a diode 12 and charges a secondary battery 14. This secondary battery 14 configures a main power source 20, together with a booster circuit 16 and an auxiliary capacitor 18.

[0025] With this embodiment of the invention, when the voltage of the secondary battery 14 drops so that it is not sufficient as the drive voltage of the timepiece, the voltage of the secondary battery 14 is converted by the booster circuit 16 to a higher voltage that makes it possible to drive the timepiece, and accumulates in the auxiliary capacitor 18. This voltage of the auxiliary capacitor 18 operates a timepiece circuit 30 as a power-supply voltage $V_{ss}$.

[0026] This timepiece circuit 30 is formed as a semiconductor device, with the configuration being such that an oscillation frequency which is preset by using a crystal oscillator 42 connected by terminals to this semiconductor device is generated, as an oscillation frequency of 32, 768 Hz in this case, then drive pulses having different polarities each second are output by dividing this oscillation output. These drive pulses are input to a drive coil 22 of a step motor that is connected to the timepiece circuit 30. This ensures that the rotor of a step motor (not shown in the figure) is driven in rotation every time a drive pulse passes therethrough, which drives the second, minute, and hour hands of the timepiece to give an analog display of time.

(2) Crystal Oscillation Circuit

[0027] A specific circuit configuration of a crystal oscillation circuit 40 that is a feature of this embodiment of the present invention is shown in Fig. 2.

[0028] This crystal oscillation circuit 40 comprises basically an inverter 60, a feed-back resistor 62, a drain resistor 64, and phase-compensation capacitors 66 and 68, and an oscillation output thereof with an oscillation frequency $f$ is output to a frequency division circuit and function circuit 81.

[0029] First and second constant voltage generation circuits 32-1 and 32-2 generate first and second constant voltages $V_{reg1}$ and $V_{reg2}$ from a voltage $V_{SS}$ that is supplied from the main power source 20. These first and second constant voltages $V_{reg1}$ and $V_{reg2}$ could be either the same voltage or different voltages. The second voltage $V_{reg2}$ is used as a power-supply voltage for the oscillation circuit drive and is applied to the inverter 60.

[0030] It should be noted that the timepiece circuit 30 of Fig. 1 is formed by a CMOS-IC 300, which is basically a semiconductor circuit, except for the crystal oscillator 42 which is shown in Fig. 11, and the CMOS-IC 300 and crystal oscillator 42 that configure the essential components of this oscillation circuit are connected by wiring 310.

[0031] In other words, the crystal oscillator 42 is connected by input-output terminals to the main circuitry portions of the oscillation circuit 40 that is formed within the CMOS-IC 300. There is therefore a danger that a surge voltage that is input through these input-output terminals could damage the internal circuitry.

[0032] This surge voltage could be one imposed from the jig used during assembly or one imposed from a human operator.

[0033] For that reason, electrostatic protection circuits 200-1 and 200-2 are provided within the crystal oscillation circuit 40.

[0034] These electrostatic protection circuits 200-1 and 200-2 are provided for each signal path connected to the input terminals. Since these electrostatic protection circuits 200-1 and 200-2 have the same configuration, the description herein takes just the electrostatic protection circuit 200-1 as an example.

[0035] This electrostatic protection circuit 200-1 comprises a resistor 70, a first electrostatic protection circuit section 210 that provides a bypass on the constant-voltage side for selectively bypassing through a first semiconductor rectifier element 72 any electrostatic voltages of a negative polarity that are introduced into the signal path of the oscillation circuit, and a second electrostatic protection circuit section 220 that provides a bypass on the ground side for selectively bypassing through a second semiconductor rectifier element 74 any electrostatic voltages of a positive polarity that are introduced into the signal path of the oscillation circuit.

[0036] This resistor 70 is connected in series with the signal path and is designed to protect the rectifier elements 72 and 74 from surge voltages.

[0037] The first and second semiconductor rectifier elements 72 and 74 are configured of diodes of a PN junction type. The diode that forms the first semiconductor rectifier element 72 is connected in the reverse direction to the output terminal side of the constant voltage ($V_{reg1}$) of the constant voltage generation circuit 32-1, and the diode that forms the second semiconductor rectifier element 74 is connected in the forward direction to the ground ($V_{DD}$) side.

[0038] This ensures that any surge voltage of a negative polarity that is introduced from the exterior is bypassed to
the constant voltage terminal \( V_{\text{reg1}} \) side and any surge voltage of a positive polarity is bypassed to the ground side, thus preventing the introduction thereof into the semiconductor circuitry.

[0039] This embodiment of the present invention is characterized in that a constant voltage \( V_{\text{reg1}} \), which does not vary even if the power-supply voltage \( V_{\text{reg2}} \) if the drive power source of the oscillation circuit does vary, is used as the constant bypass voltage of the first semiconductor rectifier element 72.

[0040] Various embodiments of this constant voltage \( V_{\text{reg1}} \) supply are illustrated in Figs. 2 to 4.

[0041] The description first concerns the electronic circuit of Fig. 2.

[0042] The electronic circuit of this embodiment comprises the plurality of constant voltage generation circuits 32-1 and 32-2 that generate different constant voltages \( V_{\text{reg1}} \) and \( V_{\text{reg2}} \), where one constant voltage \( V_{\text{reg1}} \) drives a temperature sensor 400 and the other constant voltage \( V_{\text{reg2}} \) drives the crystal oscillation circuit 40.

[0043] This embodiment of the present invention is characterized in that a constant voltage \( V_{\text{reg1}} \), which does not vary greater than the absolute value of the constant voltage \( V_{\text{reg1}} \) (also negative in this embodiment) that is always output that generates the given constant voltage \( V_{\text{reg1}} \) and a voltage-dividing circuit 33 that generates the given constant voltage \( V_{\text{reg1}} \) side.

[0044] In this case, the frequency division circuit and function circuit 81 functions both as a frequency division circuit that divides the output of the oscillation circuit 40 and also as various functional circuits.

[0045] The crystal oscillation circuit 40 of this embodiment of the invention is characterized in that it uses a constant voltage that differs from the constant voltage used for driving the oscillation circuit, more specifically, the constant voltage \( V_{\text{reg1}} \) for driving the temperature sensor 400, as the constant bypass voltage connected to the first electrostatic protection circuit section 210.

[0046] More specifically, a PN-junction diode 72 in each of the electrostatic protection circuits 200-1 and 200-2 has one end connected to the signal path side of the oscillation circuit and the other end connected to the constant voltage \( V_{\text{reg1}} \) side.

[0047] The description now turns to the embodiment shown in Fig. 3.

[0048] This embodiment of the invention comprises the constant voltage generation circuit 32-2, which generates the constant voltage \( V_{\text{reg2}} \) for driving the oscillation circuit 40, and the constant voltage generation circuit 32-1, which generates the constant bypass voltage \( V_{\text{reg1}} \) used only by the electrostatic protection circuits 200-1 and 200-2.

[0049] The crystal oscillation circuit 40 is driven by the constant voltage \( V_{\text{reg2}} \).

[0050] Each of the electrostatic protection circuits 200-1 and 200-2 has a diode 72 that functions as a first semiconductor rectifier element, which has one end connected to the constant voltage \( V_{\text{reg1}} \) for the electrostatic protection circuits.

[0051] The description now turns to the embodiment shown in Fig. 4.

[0052] The electronic circuit of this embodiment of the invention comprises a constant voltage generation circuit 32 that generates the given constant voltage \( V_{\text{reg1}} \) and a voltage-dividing circuit 33 that generates the given constant voltage \( V_{\text{reg2}} \) by dividing this constant voltage \( V_{\text{reg1}} \).

[0053] The oscillation circuit 40 uses this \( V_{\text{reg2}} \) for driving.

[0054] In addition, each of the electrostatic protection circuits 200-1 and 200-2 has a diode 72 that functions as a first semiconductor rectifier element connected to the constant voltage \( V_{\text{reg1}} \) side.

[0055] Note that the configuration could be such that the crystal oscillation circuit 40 is driven by using the constant voltage \( V_{\text{reg1}} \) and the electrostatic protection circuits 200-1 and 200-2 are connected to the \( V_{\text{reg2}} \) side, if necessary. Alternatively, if the voltage-dividing circuit 33 outputs a plurality of constant voltages as voltage-dividing outputs, the configuration could be such that one of this plurality of voltage-dividing outputs or the constant voltage \( V_{\text{reg1}} \) is used for driving the crystal oscillation circuit 40 and the remaining voltages are connected to the electrostatic protection circuits 200-1 and 200-2. A booster circuit could also be used instead of a voltage-dividing circuit.

[0056] Use of any of the configurations shown in Figs. 2 to 4 ensures that the oscillation frequency \( f_s \) of the crystal oscillation circuit 40 is always at a constant value, without any variation in the parasitic capacitances of the semiconductor rectifier elements 72 and 74, if the power-supply voltage \( V_{\text{SS}} \) of the main power source 20 or the power-supply voltage \( V_{\text{reg2}} \) of the oscillation circuit should vary for any reason.

[0057] This is described in detail below.

[0058] The relationship between the constant voltage \( V_{\text{reg1}} \) for bypass and the power-supply voltage \( V_{\text{SS}} \) is shown in Fig. 5. The power-supply voltage \( V_{\text{SS}} \) (negative in this embodiment) supplied from the main power source has a value greater than the absolute value of the constant voltage \( V_{\text{reg1}} \) (also negative in this embodiment) that is always output from each the constant voltage generation circuit 32. However, this power-supply voltage \( V_{\text{SS}} \) often varies due to factors such as variations in load or the charging state of the main power source 20, as shown in Fig. 5.

[0059] In contrast thereto, the constant voltage \( V_{\text{reg1}} \) that is output from the constant voltage generation circuit 32 is not affected much by this voltage \( V_{\text{SS}} \) of the main power source, so it is always constant.

[0060] A known problem with the prior art, which occurs when the first semiconductor rectifier element 72 is connected to the voltage \( V_{\text{SS}} \) side of the main power source 20 that has a large capacitance, is discussed below.

[0061] If the voltage \( V_{\text{SS}} \) of the main power source 20 changes, the values of the parasitic capacitances of the first and second semiconductor rectifier elements 72 and 74 formed of semiconductor devices also change.

[0062] The parasitic electrostatic capacitance C of the semiconductor rectifier elements 72 and 74 formed of PN...
junctons within the IC, particularly of the PN junction portions thereof, is generally given by the following equation:

\[ C = A \sqrt{\frac{N_D}{V_A + V_B}} \]  \hspace{1cm} (Equation 1)

where \( A \) is a constant, \( V_A \) is the applied voltage, \( N_D \) is the impurity concentration, and \( V_B \) is the potential difference across the PN junction.

From this equation, it is clear that this parasitic capacitance \( C \) varies as the power-supply voltage \( V_A (= V_{SS}) \) varies.

If this parasitic capacitance \( C \) varies, the result is that the oscillation frequency \( f_s \) of the crystal oscillation circuit 40 also changes. This is described in more detail below.

(2-1) Countermeasures Against Oscillation Frequency Variation

An equivalent circuit of the crystal oscillation circuit 40 is shown in Fig. 6A.

The crystal oscillator 42 is shown in Fig. 6B and an equivalent circuit thereof is shown in Fig. 6C.

If the equivalent circuit of Fig. 6C is used, the oscillation circuit 40 of Fig. 6A can be expressed as the circuit shown in Fig. 6D.

The oscillation frequency \( f_s \) of the LC oscillation circuit (the oscillation circuit 40) expressed by the equivalent circuit of Fig. 6D is given by the following equation:

\[ f_s \approx \frac{1}{2\pi \sqrt{L' C_g'}} \cdot f_1(C_b') \]  \hspace{1cm} (Equation 2)

It is clear from this equation that if the internal capacitance \( C_g' \) of the oscillation circuit varies, the oscillation frequency \( f_s \) also varies. In other words, since Equation 2 includes values of the parasitic capacitances \( C_{VDD} \) and \( C_{VSS} \) of the first and second semiconductor rectifier elements 72 and 74, any change in those values will make the oscillation frequency \( f_s \) change.

In contrast thereto, the first semiconductor rectifier element 72 of this -embodiment of the present invention is connected to the constant voltage \( V_{reg1} \) that does not vary. For that reason, it is possible for the crystal oscillation circuit 40 to generate an oscillation output that is always at the constant frequency \( f_s \) without being affected by the variaion of the power supply voltage \( V_{SS} \).

In addition, the above configurations ensure that the parasitic capacitances of the first and second semiconductor rectifier elements 72 and 74 are always constant. It is therefore possible to utilize the values of these parasitic capacitances actively as the phase-compensation capacitors 66 and 68. This makes it possible to ensure that the capacitances of the phase-compensation capacitors 66 and 68 of Figs. 2 to 4 are small, which in turn makes it possible to omit those phase-compensation capacitors 66 and 68.

It therefore becomes possible to reduce the number of components of the crystal oscillation circuit 40 and increase the degree of integration thereof.

This embodiment of the invention also makes it possible to increase the parasitic capacitances of the semiconductor rectifier elements 72 and 74 themselves, by utilizing the parasitic capacitances of the first and second semiconductor rectifier elements 72 and 74 as either part or the entirety of the phase-compensation capacitors 66 and 68.

In other words, if the phase-compensation capacitors 66 and 68 and the diodes 72 and 74 are provided completely separately, it is necessary to use diodes 72 and 74 having small parasitic capacitances, from the viewpoint of reducing the overall capacitance of the crystal oscillation circuit 40 and reducing the power consumption thereof. In such a case, the electrostatic breakdown resistance also deteriorates in correspondence with this parasitic capacitance.

In contrast thereto, the parasitic capacitances of the semiconductor rectifier elements 72 and 74 of this embodiment of the present invention are used actively as the phase-compensation capacitors, making it possible to use components with large parasitic capacitances as semiconductor elements. As a result, the electrostatic breakdown resistances of the elements 72 and 74 themselves are increases, making it possible to increase the electrostatic protection capabilities of the entire circuit.
Another example of the application of the present invention is shown in Fig. 7. The electrostatic protection circuit of this embodiment is characterized in the use of a third semiconductor rectifier element 78 that is connected in the reverse direction to the main power source \( V_{SS} \). Since this makes it possible to configure a surge voltage bypass circuit on the large-capacitance main power source 20 side, it enables an increase in the electrostatic breakdown resistance of the electrostatic protection circuit 200.

Note that variations in the power-supply voltage \( V_{SS} \) will have an effect in that they will cause the parasitic capacitance of the third semiconductor rectifier element 78 to vary. For that reason, amount of variation of the parasitic capacitance of the third semiconductor rectifier element 78 is preferably set so that it has only a few percentage points of effect with respect to the amount of variation of the total parasitic capacitance of the first semiconductor rectifier element 72 and the third semiconductor rectifier element 78, by setting the value of the parasitic capacitance of the first semiconductor rectifier element 72 one-digit to two-digit larger than that of the parasitic capacitance of the third semiconductor rectifier element 78. This ensures that the value of the electrostatic capacitance of the entire circuit is always stable, making it possible to obtain a more stable oscillation output.

An example of a conventional electrostatic protection circuit in which the semiconductor rectifier element 72 is connected to the main power source \( V_{SS} \) side is shown in Fig. 8. In the conventional example of Fig. 8, the first semiconductor rectifier element 72, which is connected to the main power source that varies with the power-supply voltage \( V_{SS} \), is represented in circuit terms as an element with variable parasitic capacitance \( C_{vss} \).

Studies on the frequency deviation in an example of a crystal oscillation circuit that uses this conventional electrostatic protection circuit are described below.

In the conventional circuit of Fig. 8, actual measured values of \( C_G \) and \( C_D \), which are the total capacitances of the internal circuitry of the IC (semiconductor device) comprising the electrostatic protection circuit 200, as seen from the gate terminal and drain terminal of a transistor that configures a gate 60 of the crystal oscillation circuit 40, are given by the equations below. In this case, since the resistance \( R_f \) of a resistor 62 is extremely high, the value of \( C_{DO} \) can be omitted from the value of \( C_G \) in the following equations, as can the value of \( C_{GO} \) from the value of \( C_D \).

\[
C_G = C_{CD} + C_{VDD} + C_{VSS} + C_{GP} = 10.8 \text{ (PF)}
\]
\[
C_D = C_{DO} + C_{VDD} + C_{VSS} + C_{DP} = 6.1 \text{ (PF)}
\]

\[\ldots \text{(Equation 3)}\]

When the power-supply voltage \( V_{SS} \) varies from 1.1 volts to 2.4 volts in this conventional circuit, the amount of variation of the parasitic capacitance \( C_{vss} \) of the first semiconductor rectifier element 72 is \( \Delta C_{vss} = 0.07 \text{ (PF)} \).

Studies were then performed on how much the amount of variation of this parasitic capacitance affects the overall electrostatic capacitance of the crystal oscillation circuit 40.

First of all, if the ratio of the amount of variation of the parasitic capacitance of the electrostatic protection circuit 200-2 with respect to \( C_G \) of Fig. 3 is obtained, it can be expressed as follows:

\[
\frac{\Delta C_{vss}}{C_{GO} + C_{VDD} + C_{VSS} + C_{GP}} = \frac{7}{1080} \]
\[\ldots \text{(Equation 4)}\]

Similarly, the ratio of the amount of variation of the parasitic capacitance of the electrostatic protection circuit 200-1 with respect to \( C_D \) of Fig. 3 is given by:
In this case, CGP and CDP denote the corresponding wiring capacitances of the crystal oscillation circuit 40.

If the value of the frequency deviation of the oscillation circuit is obtained from this amount of variation of parasitic capacitance, it is \((\Delta f/\Delta V) = 3\) (PPM). This is approximately 8 seconds if calculated over a month. If the permissible monthly variation of a timepiece is on the order of 15 seconds, 8 seconds of that 15 seconds could be taken up by variations in the parasitic capacitance, which cannot possibly be permitted.

In contrast thereto, the first semiconductor rectifier element 72 is connected to the power source \(V_{reg1}\) that does not vary, as shown in Figs. 2 to 4, so that the variation in the parasitic capacitance thereof can be substantially ignored and thus the frequency deviation of the oscillation frequency of the crystal oscillation circuit 40 itself is improved to a degree such that it can be ignored, in comparison with the conventional circuit.

Similar studies have been performed on the crystal oscillation circuit 40 that uses the electrostatic protection circuit of the other embodiment shown in Fig. 7. An equivalent circuit of this electrostatic protection circuit is shown in Fig. 9. In this case, the third semiconductor rectifier element 78 forms an element in which the parasitic capacitance \(C_{vss}\) varies.

In the circuit shown in Fig. 9 too, the parasitic capacitance of the third semiconductor rectifier element 78 is formed to be sufficiently smaller than the parasitic capacitance of the first semiconductor rectifier element 72, so that the frequency deviation of the overall circuit can be made much smaller than that in which the electrostatic protection circuit of Fig. 8 is used, even if this parasitic capacitance \(C_{vss}\) varies.

(5) Embodiments with Constant Bypass Voltage \(V_{reg1}\) Connected to Electrostatic Protection Circuit

The constant bypass voltage \(V_{reg1}\) that is connected to the electrostatic protection circuit 200-1 is set to a value such that the first and second semiconductor rectifier elements 72 and 74 do not turn on because of a change in voltage in the signal path generated by that leakage current, even if a leakage current is generated between the signal path of the crystal oscillation circuit 40 and the line for the power-supply voltage \(V_{ss}\).

If this power-supply voltage is assumed to be \(V_{ss}\), the forward-direction on-voltage of each of the semiconductor rectifier elements 72 and 74 is \(V_{fon}\), and the potential difference between the signal line and the power-supply voltage line when a leakage current is generated is \(V_R\), as shown by way of example in Fig. 12, the constant bypass voltage \(|V_{reg1}|\) is set to a value such that the following inequality is satisfied, within a expected operating voltage for the power-supply voltage \(|V_{ss}|\) (within the range of 1.2 to 2 V, by way of example):

\[ |V_{reg1}| > |V_{ss}| - V_R - V_{fon} \]

This makes it possible to maintain stable oscillation, without being affected by any leakage current between the signal path of the oscillation circuit 40 and the power-supply voltage \(V_{ss}\) line, even if such a leakage current occurs. This is described in detail below.

The descriptions of the above embodiments related to examples in which the constant voltage generation circuits 32-1 and 32-2 are formed separately and the constant bypass voltage \(V_{reg1}\) connected to the electrostatic protection circuits 200-1 and 200-2 is formed separately from the constant voltage \(V_{reg2}\) supplied to the oscillation circuit 40. To simplify the description herein, an idealized situation is used in which the two constant voltage generation circuits 32 are formed to be the same circuit and the same constant voltage \(V_{reg}\) is provided to the electrostatic protection circuits 200-1 and 200-2 and the oscillation circuit 40.

In the circuit of this example, the constant bypass voltage \(V_{reg1}\) connected to the electrostatic protection circuits 200-1 and 200-2 is preferably set to a value such that the oscillation of the oscillation circuit 40 does not stop, even if a leakage current caused by a change in the environment, such as a humidity change, occurs between input-output terminals 71-1 and 71-2 of the oscillation circuit 40 and a line 73 for the power-supply voltage \(V_{ss}\).

In other words, a leakage current corresponding to an environmental change such as a change in humidity...
could occur between the input-output terminals 71-1 and 71-2 of the oscillation circuit 40, which are attached to the electrostatic protection circuits 200-1 and 200-2, and the line 73 of the power-supply voltage Vss.

[0096] This leakage current can occur when the IC is mounted on a circuit board, as shown in Fig. 11, and the insulation resistance of the circuit board has dropped because of an environmental change, such as a change in humidity. More specifically, a drop in the insulation resistance can occur between a wiring pattern 310 of the circuit board shown in Fig. 11, which is connected to input-output terminals of the oscillation circuit, and a wiring pattern (power-supply voltage line) for the power-supply voltage $V_{SS}$. This phenomenon is remarkably common when the material of the circuit board is a polyimide.

[0097] An equivalent circuit of Fig. 12 shows the state when a leakage current has occurred between the input-output terminals 71-1 and 71-2 of the oscillation circuit 40 and the line 73 of the power-supply voltage $V_{SS}$.

[0098] When a leakage current occurs, a forward-direction voltage $V_F$ given by the equation below is applied to a semiconductor rectifier element D2 (72) that forms one of the electrostatic protection circuits 200-1 and 200-2 (the voltage drop due to the resistance of the electrostatic protection circuits 200-1 and 200-2 is small so can be ignored).

$$V_F = |V_{SS}| - V_R - |V_{reg}| \quad ...... \quad (Equation \ 6)$$

[0099] In this case, assume that the forward-direction on-voltage that turns on the semiconductor rectifier elements 72 and 74 is $V_{Fon}$. This forward-direction on-voltage is usually on the order of 0.6 V. If the forward-direction voltage $V_F$ has a value greater than that of this forward-direction on-voltage, the semiconductor rectifier element D2 turns on and a forward-direction current flows.

[0100] For that reason, the forward-direction voltage $V_F$ is set to be less than the value of $V_{Fon}$.

$$V_F < V_{Fon} = 0.6 \ (V) \quad ...... \quad (Equation \ 7)$$

[0101] (If the polarity of the power-supply voltage is that of a positive power source $V_{DD}$, using $V_{SS}$ as a reference potential, a forward-direction current flows in the semiconductor rectifier element D1.)

[0102] This flow of forward-direction current causes the following problems:

- The constant voltage $V_{reg}$ moves towards the power-supply voltage $V_{SS}$ side (increase in absolute value).
- Since the constant voltage $V_{reg}$ changes, the parasitic capacitances of the semiconductor rectifier elements of the electrostatic protection circuit also change and the frequency voltage deviation increases.
- The change in constant voltage $V_{reg}$ towards the power-supply voltage $V_{SS}$ side (increase in absolute value) leads to an increase in the current consumption of the oscillation circuit.
- If the semiconductor rectifier element D2 goes into a completely on state, the oscillation of the oscillation circuit will halt.

[0103] To ensure that none of the above problems occur, more specifically, to ensure that the semiconductor rectifier element D2 is not turned on, the constant bypass voltage $V_{reg}$ connected to the electrostatic protection circuits 200-1 and 200-2 must be set to a value that satisfies the above Equations 6 and 7.

[0104] For a rechargeable timepiece, the power-supply voltage $V_{SS}$ is on the order of -2 V, so the constant voltage $V_{reg}$ that satisfies both Equations 6 and 7 is given by the equation below. In other words, to ensure that the above problems do not occur, the constant bypass voltage $V_{reg}$ must be set to satisfy the equation below.

[0105] More specifically, the value of the constant bypass voltage $V_{reg}$ must be set to a value that satisfies the following equation within the expected operating range (a range of 1.2 to 2 V, for example), as the voltage range of the power-supply voltage $V_{SS}$ that enables the oscillation circuit to operate:

$$|V_{reg}| > |V_{SS}| - V_R - V_{Fon} = 1.4 \ (V) - V_R \quad ...... \quad (Equation \ 8)$$
The use of the above-described configuration ensures that, even if a leakage current occurs between a signal of the oscillation circuit 40 (such as the input-output terminals 71-1 and 71-2) and the line 73 of the power-supply voltage V_SSS, the semiconductor rectifier element 72 is not turned on by any voltage change in the signal path (the input-output terminals 71-1 and 71-2) of the oscillation circuit 40 that may be caused by that leakage current. As a result, it is possible to ensure the stable operation of the oscillation circuit even in such a leakage current should occur.

[0110] In other words, if the constant bypass voltage V_{reg1} of the electrostatic protection circuits 200-1 and 200-2 is made to be the same constant voltage by using the consumption of the oscillation circuit and the stability of the oscillation frequency.

Equation 9 is satisfied. This makes it possible to solve the two technical problems of a reduction in the current bypass voltage V_{reg1} and the constant voltage V_{reg2} for driving the oscillation circuit 40 are set such that the inequality is connected to the electrostatic protection circuits 200-1 and 200-2. The output V_{reg2} of the constant voltage generation circuit 32-1 and 32-2 is set to a small absolute value that satisfies Equation 8, thus enabling stable driving of the oscillation circuit. (In that case, V_{reg} of Fig. 8 becomes V_{DD}.)

As described previously, if the constant voltage V_{reg2} of the oscillation circuit 40 and the constant bypass voltage V_{reg1} of the electrostatic protection circuits 200-1 and 200-2 are made to be the same constant voltage by using the constant voltage generation circuit 32 in common, a problem arises in that it is not possible to set the constant voltage for driving the oscillation circuit 40 to a small value, with the aim of reducing current consumption.

In other words, if the constant bypass voltage V_{reg1} of the electrostatic protection circuits 200-1 and 200-2 is the same as the constant voltage V_{reg2} used for driving the oscillation circuit 40, it is no longer possible to set the constant voltage V_{reg2} to be small with the aim of reducing the current consumption of the oscillation circuit 40, so long as V_SSS of Equation 8 does not become large, in other words, so long as a circuit board with a large insulation resistance is not used.

In order to solve that problem, the constant bypass voltage V_{reg1} is preferably set to be a constant voltage that is separate from the expected constant voltage V_{reg1} for driving the oscillation circuit 40. More specifically, it is preferable to use separate constant voltage generation circuits 32-1 and 32-2 as shown in Figs. 2 to 4, and separately generate the constant bypass voltage V_{reg1} and the constant voltage V_{reg2} for driving the oscillation circuit. It is also preferable that the constant bypass voltage V_{reg1} supplied to the constant voltage generation circuit 32 is set to satisfy Equation 8 and also that the constant voltage V_{reg2} supplied for driving the oscillation circuit 40 is set to a small absolute value that optimizes the low power consumption of the oscillation circuit 40. This makes it possible to ensure both of the conditions of reduced current and power consumptions of the oscillation circuit 40 and a stable oscillation frequency of the oscillation circuit 40.

In other words, the output V_{reg1} of the constant voltage generation circuit 32-1 is set to satisfy Equation 8 and is connected to the electrostatic protection circuits 200-1 and 200-2. The output V_{reg2} of the constant voltage generation circuit 32-2 is set to a small absolute value so as to optimize the reduction in current consumption of the oscillation circuit 40. This configuration makes it possible to both reduce the current consumption of the oscillation circuit 40 and also ensure that the oscillation frequency of the oscillation circuit 40 is stable.

If there is a plurality of constant voltage generation circuits, it is possible to ensure that any transient change in the constant voltage due to discharge currents during electrostatic application do not affect the oscillation circuit, by setting the constant voltage of the electrostatic protection circuit to be separate from the constant voltage of the oscillation circuit.

It should be noted, however, that the constant bypass voltage V_{reg1} of the electrostatic protection circuits 200-1 and 200-2 and the constant voltage V_{reg2} for driving the oscillation circuit 40 must satisfy the condition of Equation 9 given below (if Equation 9 is not satisfied, a forward-direction current will flow in the semiconductor rectifier element D2 every time the oscillation output reaches the level of V_{reg2} during normal operation).

\[ |V_{reg1}| > |V_{reg2}| \] \[ \text{...... (Equation 9)} \]

In other words, if the constant bypass voltage V_{reg1} is generated as a constant voltage that is supplied separately from the constant voltage V_{reg2} that is supplied as the power-supply voltage for the oscillation circuit 40, that constant bypass voltage V_{reg1} and the constant voltage V_{reg2} for driving the oscillation circuit 40 are set such that the inequality of Equation 9 is satisfied. This makes it possible to solve the two technical problems of a reduction in the current consumption of the oscillation circuit and the stability of the oscillation frequency.

As described above, this example could either provide the same constant voltage V_{reg} for the electrostatic protection circuits 200-1 and 200-2 and the oscillation circuit 40, or it could provide the constant bypass voltage V_{reg1} and the V_{reg2} for driving separately, in order to reduce the current consumption of the oscillation circuit.
5-2 Second example useful for understanding the invention

[0116] It is preferable that the constant bypass voltage \( V_{\text{reg1}} \) used in the circuit of the present invention is a constant voltage having a temperature characteristic that ensures a small voltage variation with respect to a temperature change. This is described in detail below.

[0117] The voltage \( V_{\text{reg2}} \) for driving the oscillation circuit 40 is set in such a manner that it has the same slope as the temperature characteristic of an oscillation-stopping voltage \( V_{\text{sto}} \) of the oscillation circuit 40, as shown in Fig. 13.

[0118] This ensures that the condition of Equation 10 is satisfied, so that the oscillation of the oscillation circuit 40 does not stop within the guaranteed operating temperature range of the oscillation circuit 40, and also sets the constant voltage \( V_{\text{reg2}} \) to a small value that approaches the oscillation-stopping voltage, to reduce the current consumption of the oscillation circuit 40 to the limit.

\[ |V_{\text{reg2}}| > |V_{\text{sto}}| \quad \ldots \ldots \quad \text{(Equation 10)} \]

[0119] This means that, if the oscillation-stopping voltage \( V_{\text{sto}} \) of the oscillation circuit 40 has a large temperature characteristic, the temperature characteristic of the constant voltage \( V_{\text{reg2}} \) for driving the oscillation circuit 40 will also be large.

[0120] If the constant voltage \( V_{\text{reg2}} \) for driving the oscillation is used as the constant bypass voltage \( V_{\text{reg1}} \) of the electrostatic protection circuit 200, therefore, the parasitic capacitances of the semiconductor rectifier elements of the electrostatic protection circuit 200 will also change with temperature. This leads to a problem in that the oscillation frequency of the oscillation circuit 40 will also change, and the oscillation stability of the oscillation circuit will deteriorate.

[0121] For that reason, the circuit of this embodiment of the invention generates two different constant voltages: the constant voltage \( V_{\text{reg2}} \) for driving the oscillation circuit and the constant bypass voltage \( V_{\text{reg1}} \) of the electrostatic protection circuit 200, as shown in Figs. 2 to 4. In addition, a constant voltage that has a smaller temperature characteristic than the constant voltage \( V_{\text{reg2}} \) for driving the oscillation circuit is used as the constant bypass voltage \( V_{\text{reg1}} \). This makes it possible to suppress changes in the parasitic capacitances of the semiconductor rectifier elements of the electrostatic protection circuit 200 within the guaranteed operating temperature range of the oscillation circuit 40, by using a constant voltage having a small temperature characteristic as the constant bypass voltage \( V_{\text{reg1}} \), thus making it possible to increase the stability of the oscillation frequency of the oscillation circuit 40.

[0122] Note that the constant voltage \( V_{\text{reg1}} \) for driving the temperature sensor 400 is preferably used as the above-described constant bypass voltage \( V_{\text{reg1}} \) with a shallow temperature characteristic, as shown by way of example in Fig. 2. The slope of the temperature characteristic of the constant voltage \( V_{\text{reg1}} \) for driving the temperature sensor 400 is set to be 1 mV/°C or less, to enable accurate measurement of temperature that is not affected by changes in the ambient temperature. For that reason, the voltage remains substantially unchanged, regardless of any changes in the ambient temperature.

[0123] An example of a constant voltage generation circuit that generates the constant voltage \( V_{\text{reg1}} \) for driving a temperature sensor, which has a temperature characteristic with a shallow slope, is shown in Fig. 14.

[0124] In this constant voltage generation circuit 32-1, N \( N_{\text{ch}} \)-transistors I262 and I263 are constructed to the same dimensions, and the current amplification ratio of the transistors I262 and I263 is given by:

\[ \beta_{\text{nd}} = \beta_{\text{ne}} \]

In addition, if I262 is a depletion type of transistor and I263 is an enhancement type of transistor, the threshold voltages thereof should be such that:

\[ V_{\text{tnd}} \neq V_{\text{tne}} \]

[0125] In that case, the output \( V_{\text{reg1}} \) of the constant voltage generation circuit 32-1 is given by the equation below, to
generate a constant voltage $V_{reg1}$ that has a difference in threshold voltage between I262 and I263.

\[ V_{gs} = V_{tne} - V_{tnd} = V_{reg1} \]

[0126] Since the threshold voltages of the transistors I262 and I263 have the same temperature characteristics, the threshold voltage difference thereof does not change and thus a constant voltage $V_{reg1}$ that is not dependent on temperature is generated.

[0127] It should be noted, however, that the constant voltage $V_{reg1}$ of the electrostatic protection circuit and the constant voltage $V_{reg2}$ of the oscillation circuit must be such as to satisfy the inequalities of Equations 8 and 9.

5-3 First embodiment of the present invention

[0128] If it is assumed that an electrostatic voltage of a negative polarity is applied to the circuit of this embodiment, as shown in Fig. 15 by way of example, a discharge pathway 1000 is formed to discharge this negative-polarity charge to a side of the constant bypass voltage $V_{reg1}$ through the electrostatic protection circuit (first semiconductor rectifier element) 200.

[0129] If the circuit of this embodiment has a plurality of constant voltage generation circuits 32, therefore, it is preferable to use the constant voltage of the constant voltage generation circuit 32 that has the largest constant voltage drive region (over the entire circuitry to be driven at the constant voltage) as the constant bypass voltage $V_{reg1}$ for the electrostatic protection circuit. This is discussed in detail below.

[0130] In Fig. 15, D3 denotes an equivalent circuit of the entire circuitry to be driven at a constant voltage by the constant voltage generation circuit 32 (except for the electrostatic protection circuit 200). Since the circuitry to be driven at the constant voltage is basically formed of semiconductors, it can be represented schematically as a parasitic diode D3, as shown in this figure.

[0131] The capacitance of this schematic parasitic diode D3 increases as the number of circuits driven by the constant voltage increases, as mentioned previously.

[0132] In this case, this increase in the number of circuits driven by the constant voltage and the resultant increase in the capacitance of the parasitic diode D3 leads to an increase in the constant voltage drive region. The semiconductor rectifier element D3 represents a parasitic diode created within the constant voltage drive region.

[0133] If an electrostatic voltage of a negative polarity has been applied, the avalanche phenomenon in the parasitic diode D3 is utilized to create the discharge pathway 1000.

[0134] In this case, if the dimensions of the circuitry to be driven at the constant voltage increases, more specifically, if the constant voltage drive region increases, the surface area of the parasitic diode D3 of Fig. 15 that is represented as an equivalent circuit also increases, the discharge capability thereof rises, and, as a result, the electrostatic-resistance characteristic of the parasitic diode D3 becomes favorable.

[0135] For the above reason, if there are constant voltages supplied from a plurality of constant voltage generation circuits 32, it is preferable to use the constant voltage with the largest constant voltage drive region (largest circuit dimensions to be driven at the constant voltage) as the constant bypass voltage $V_{reg1}$.

[0136] It is also possible to utilize a configuration in which a semiconductor rectifier element D4 is deliberately connected parallel to the constant voltage generation circuit 32, but separate from the parasitic diode D3, so that it becomes part of the discharge circuit 1000.

[0137] In this case too, the constant bypass voltage $V_{reg1}$ of the electrostatic protection circuit 200 and the constant voltage $V_{reg2}$ for driving the oscillation circuit 40 must be such as to satisfy the conditions of Equation 8 and 9.

5-4 Second embodiment of the present invention

[0138] The embodiments herein have been described with respect to examples in which the positive power source $V_{DD}$ acts as a reference potential and the power-supply voltage $V_{SS}$ and a constant voltage $V_{reg}$ have negative polarity, but the present invention can equally well be applied only to a configuration in which the negative power source $V_{SS}$ acts as the reference potential and the power-supply voltage $V_{DD}$ and a constant voltage $V_{reg}$ have positive polarity.

(6) Miscellaneous

[0139] Note that although the embodiments described herein deal with examples in which diodes are used as semiconductor rectifier elements, it is also possible to form protective circuits with other types of semiconductor rectifier element if necessary. For example, electrostatic protection circuits could be formed by using bipolar transistors as
Furthermore, although the above embodiments were described as relating to an example in which the present invention is applied to a portable wristwatch, the oscillation circuit and electrostatic protection circuit in accordance with the present invention could also be applied to other applications, such as use as a reference signal source in various types of electronic equipment in mobile phones and portable computer terminal, where the driving of a drive section (circuitry) of that electronic equipment is based on an output signal of that reference signal source.

Claims

1. An oscillation circuit comprising:

   a first electrostatic protection circuit (210) connected between a signal path of the oscillation circuit and a constant-voltage side, and bypassing an electrostatic voltage of a first polarity that intrudes into the signal path to a side of a constant bypass voltage $V_{reg1}$ through a first semiconductor rectifier element (72); and
   
   a second electrostatic protection circuit (220) connected between the signal path and a reference potential side, and bypassing an electrostatic voltage of a second polarity that intrudes into the signal path to the reference potential side through a second semiconductor rectifier element (74),

   wherein the constant bypass voltage $V_{reg1}$ is a constant voltage that is supplied separately from a power-supply voltage of the oscillation circuit,

   characterized in that

   the constant bypass voltage $V_{reg1}$ and a constant voltage $V_{reg2}$ supplied as the power-supply voltage of the oscillation circuit are set in such a manner that the following inequality is satisfied: $|V_{reg1}| > |V_{reg2}|$;

   a capacitance of a parasitic diode (D3) that is provided between the constant bypass voltage $V_{reg1}$ and the reference potential is set larger than a capacitance of a parasitic diode that is provided between the constant voltage $V_{reg2}$ supplied as the power-supply voltage of the oscillation circuit and the reference potential; and

   a discharging semiconductor rectifier element (D4) for discharging an electrostatic voltage of a first polarity that intrudes into the signal path to a side of a constant bypass voltage through the first semiconductor rectifier element (72), is provided between an output of the constant voltage supply circuit which supplies the constant bypass voltage $V_{reg1}$ and the reference potential.

2. The oscillation circuit as defined by claim 1, wherein one of a supplied constant voltage from a constant voltage supply circuit (32-1) and a constant voltage obtained by dividing or stepping up the supplied constant voltage is used as a power-supply voltage for the oscillation circuit, and the other is used as the constant bypass voltage.

3. The oscillation circuit as defined by any one of claims 1 to 2, wherein a constant voltage having a temperature characteristic that ensures a smaller voltage variation than a constant voltage supplied as a power-supply voltage for the oscillation circuit with respect to a temperature change is used as the constant bypass voltage $V_{reg1}$.

4. The oscillation circuit as defined by any one of claim 3, wherein a discharging semiconductor rectifier element for discharging an electrostatic voltage of a first polarity that intrudes into the signal path to a side of a constant bypass voltage through the first semiconductor rectifier element (72), is provided between an output of the constant voltage supply circuit which supplies the constant bypass voltage $V_{reg1}$ and the reference potential.

5. The oscillation circuit as defined by any one of claims 1, 2 and 4, wherein the discharging semiconductor rectifier element is a parasitic diode (D3).

6. The oscillation circuit as defined by claim 1 or 5, wherein the first electrostatic protection circuit (210) comprises a third semiconductor rectifier element connected between the signal path of the oscillation circuit and a main power source, and bypassing an electrostatic voltage of a first polarity that intrudes into the signal path to the main power-supply voltage side.

7. The oscillation circuit as defined by claim 6, wherein the parasitic capacitance of the third semiconductor rectifier element is set to be a value that is smaller than the parasitic capacitance of the first semiconductor rectifier (72).

8. The oscillation circuit as defined by any one of claims 1 to 7, wherein at least one portion of the parasitic capacitance of the respective semiconductor rectifier elements is used as a phase-compensation capacitor.
9. An electronic circuit comprising the oscillation circuit defined by any one of claims to 8 and a drive circuit adapted to drive a driven section, based on an output of the oscillation circuit.

10. A semiconductor device comprising the oscillation circuit defined by any one of claims 1 to 8 and a circuit board on which the oscillation circuit is mounted.

11. A timepiece comprising the oscillation circuit defined by any one of claims 1 to 8 and a time display section which is adapted to display a time based on the oscillation circuit.

12. Electronic equipment comprising the oscillation circuit defined by any one of claims to 8 and a drive circuit which is adapted to drive a driven section, based on an output of the oscillation circuit.

Patentansprüche

1. Oszillationsschaltung mit:

einer ersten elektrostatischen Schutzschaltung (210), die zwischen einem Signalweg der Oszillationsschaltung und einer Konstantspannungsseite geschaltet ist und eine elektrostatische Spannung einer ersten Polarität umgeht, die in den Signalweg zu einer Seite einer Konstantumgehungsspannung $V_{reg1}$ durch ein erstes Halbleiter-Gleichrichterelement (72) eindringt; und
einer zweiten elektrostatischen Schutzschaltung (220), die zwischen dem Signalweg und einer Bezugspotentialseite geschaltet ist und eine elektrostatische Spannung einer zweiten Polarität umgeht, die in den Signalweg zur Bezugspotentialseite durch ein zweites Halbleiter-Gleichrichterelement (74) eindringt,

wobei die Konstantumgehungsspannung $V_{reg1}$ eine konstante Spannung ist, die getrennt von einer Leistungszufuhrspannung der Oszillationsschaltung zugeführt wird,

dadurch gekennzeichnet, dass
die Konstantumgehungsspannung $V_{reg1}$ und eine konstante Spannung $V_{reg2}$, die als die Leistungszufuhrspannung der Oszillationsschaltung zugeführt wird, auf eine solche Weise eingestellt sind, dass die folgende Ungleichung erfüllt ist: $|V_{reg1}|>|V_{reg2}|$; und
eine Kapazität einer parasitischen Diode (D3), die zwischen der Konstantumgehungsspannung $V_{reg1}$ und dem Bezugspotential vorgesehen ist, größer eingestellt ist als eine Kapazität einer parasitischen Diode, die zwischen der konstanten Spannung $V_{reg2}$, die als die Leistungszufuhrspannung der Oszillationsschaltung zugeführt wird, und dem Bezugspotential geschaltet ist; und
ein Entladungshalbleiter-Gleichrichterelement (D4) zum Entladen einer elektrostatischen Spannung einer ersten Polarität, die in den Signalweg zu einer Seite einer Konstantumgehungsspannung durch das erste Halbleiter-Gleichrichterelement (72) eindringt, zwischen einer Ausgabe der Konstantspannungszufuhrspannung, die die Konstantumgehungsspannung $V_{reg1}$ zuführt, und dem Bezugspotential vorgesehen ist.

2. Oszillationsschaltung nach Anspruch 1, wobei eine von einer zugeführten konstanten Spannung von einer Konstantspannungs-Zufuhrspannung (32-1) und einer konstanten Spannung, die durch Aufteilen oder Hinauftransformieren der zugeführten konstanten Spannung erhalten wird, als die Leistungszufuhrspannung für die Oszillationsschaltung und die andere als die Konstantumgehungsschaltung verwendet wird.

3. Oszillationsschaltung nach irgendeinem der Ansprüche 1 bis 2, wobei eine konstante Spannung mit einer Temperaturabhängigkeit, die eine kleinere Spannungsschwankung als eine konstante Spannung sicherstellt, die als Leistungszufuhrspannung für die Oszillationsschaltung in Bezug auf eine Temperaturänderung zugeführt wird, als die Konstantumgehungsspannung $V_{reg1}$ verwendet wird.

4. Oszillationsschaltung nach irgendeinem des Anspruchs 3, wobei ein Entladungshalbleiter-Gleichrichterelement zum Entladen einer elektrostatischen Spannung einer ersten Polarität, die in den Signalweg auf eine Seite einer konstanten Umgehungsspannung durch das erste Halbleiter-Gleichrichterelement (72) eindringt, zwischen einer Ausgabe der Konstantspannungs-Zufuhrspannung, die die konstante Umgehungsspannung $V_{reg1}$ zuführt, und dem Bezugspotenzial vorgesehen ist.

5. Oszillationsschaltung nach irgendeinem der Ansprüche 1, 2 und 4, wobei das Entladungshalbleiter-Gleichrichterelement eine parasitische Diode (D3) ist.
Reivendications

1. Circuit d’oscillation comprenant :
   un premier circuit (210) de protection électrostatique, monté entre un trajet de signal du circuit d’oscillation et un côté à tension constante et mettant en dérivation une tension électrostatique d’une première polarité, qui pénètre dans le trajet du signal vers un côté d’une tension \( V_{\text{reg1}} \) de dérivation constante en passant par un premier élément (72) redresseur à semiconducteur ; et
   un deuxième circuit (220) de protection électrostatique, monté entre le trajet du signal et un côté de potentiel de référence et mettant en dérivation une tension électrostatique d’une deuxième polarité, qui pénètre dans le trajet du signal vers le côté du potentiel de référence en passant par un deuxième élément (74) redresseur à semiconducteur,
   dans lequel la tension \( V_{\text{reg1}} \) de dérivation constante est une tension constante, qui est fournie séparément d’une tension d’alimentation en courant du circuit d’oscillation,
   caractérisé en ce que
   la tension \( V_{\text{reg1}} \) de dérivation constante et une tension \( V_{\text{reg2}} \) constante fournie comme tension d’alimentation en courant du circuit d’oscillation sont fixées d’une manière telle que l’inégalité suivante est satisfaite : \( |V_{\text{reg1}}| > |V_{\text{reg2}}| \) :
   une capacité d’une diode (D3) parasite, qui est prévue entre la tension \( V_{\text{reg1}} \) de dérivation constante et le potentiel de référence, est fixée de manière plus grande qu’une capacité d’une diode parasite, qui est prévue entre la tension \( V_{\text{reg2}} \) constante fournie comme tension d’alimentation en courant du circuit d’oscillation et le potentiel de référence ; et
   un élément (D4) redresseur à semiconducteur de décharge, pour décharger une tension électrostatique d’une première polarité, qui pénètre dans le trajet du signal vers un côté d’une tension de dérivation constante en passant par le premier élément (72) redresseur à semiconducteur, est prévu entre une sortie du circuit d’alimentation en tension constante, qui fournit la tension \( V_{\text{reg1}} \) de dérivation constante, et le potentiel de référence.

2. Circuit d’oscillation tel que défini par la revendication 1, dans lequel l’une d’une tension constante, fournie par un circuit (32-1) d’alimentation en tension constante et d’une tension constante obtenue en divisant ou en élevant la tension constante fournie, est utilisée comme tension d’alimentation en courant du circuit d’oscillation et l’autre est utilisée comme tension de dérivation constante.
3. Circuit d’oscillation tel que défini par l’une quelconque des revendications 1 à 2, dans lequel une tension constante ayant une caractéristique de température, qui assure une variation de tension plus petite qu’une tension constante fournie comme tension d’alimentation en courant du circuit d’oscillation en fonction de variations de température, est utilisée comme tension V_{reg1} de dérivation constante.

4. Circuit d’oscillation tel que défini par l’une quelconque des revendications 1 à 3, dans lequel un élément redresseur à semiconducteur de décharge, pour décharger une tension électrostatique d’une première polarité, qui pénètre dans le trajet du signal vers un côté d’une tension de dérivation constante en passant par le premier élément (72) redresseur à semiconducteur, est prévu entre une sortie du circuit d’alimentation en tension constante, qui fournit la tension V_{reg1} de dérivation constante et le potentiel de référence.

5. Circuit d’oscillation tel que défini par l’une quelconque des revendications 1, 2 et 4, dans lequel l’élément redresseur à semiconducteur de décharge est une diode (D3) parasite.

6. Circuit d’oscillation tel que défini par les revendications 1, 2 ou 5, dans lequel le circuit (210) de protection électrostatique comprend un troisième élément redresseur à semiconducteur, monté entre le trajet du signal du circuit d’oscillation et une source de courant principale et mettant en dérivation une tension électrostatique d’une première polarité, qui pénètre dans le trajet du signal vers le côté de tension d’alimentation en courant principale.

7. Circuit d’oscillation tel que défini par la revendication 6, dans lequel la capacité parasite du troisième élément redresseur à semiconducteur est fixée de manière à avoir une valeur qui est plus petite que la capacité parasite du premier redresseur (72) à semiconducteur.

8. Circuit d’oscillation tel que défini par l’une quelconque des revendications 1 à 7, dans lequel au moins une partie de la capacité parasite des éléments redresseurs à semiconducteurs respectifs est utilisée comme condensateur à compensation de phase.

9. Circuit électronique comprenant le circuit d’oscillation défini par l’une quelconque des revendications 1 à 8 et un circuit d’attaque, qui est conçu pour attaquer une section attaquée sur la base d’une sortie du circuit d’oscillation.

10. Dispositif à semiconducteur comprenant le circuit d’oscillation défini par l’une quelconque des revendications 1 à 8 et une plaquette de circuit, sur lequel le circuit d’oscillation est monté.

11. Pièce d’horloge comprenant le circuit d’oscillation défini par l’une quelconque des revendications 1 à 8 et une section d’affichage du temps, qui est conçue pour afficher un temps sur la base du circuit d’oscillation.

12. Equipement électronique comprenant le circuit d’oscillation défini par l’une quelconque des revendications 1 à 8 et un circuit d’attaque, qui est conçu pour attaquer une section attaquée sur la base d’une sortie du circuit d’oscillation.
FIG. 5
FIG. 6A

FIG. 6B

FIG. 6C

FIG. 6D

$C_g'$; $C_{go}$, $C_o$, $C_p$, $C_{vdd}$

$C_d'$; $C_{do}$, $C_o$, $C_p$, $C_{vss}$
FIG. 12

Oscillation Circuit Input or Output

FIG. 13

Guaranteed Operating Temperature of Oscillation Circuit
REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 9205325 A [0004] [0005]
- JP 10160867 A [0004]