

SEMICONDUCTOR DEVICE AND METERING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority under 35 USC 119 from Japanese Patent Application No. 2012-203060, filed on Sep. 14, 2012, the disclosure of which is incorporated by reference herein.

BACKGROUND

[0002] 1. Technical Field

[0003] The present invention relates to a semiconductor device and to a metering apparatus, and in particular relates to a semiconductor device including an oscillation circuit containing an oscillator, and to a metering apparatus containing such a semiconductor device.

[0004] 2. Description of the Related Art

[0005] There has been growing interest recently into “smart meters” that are implemented by adding a high performance communication function to a meter, such as electricity, gas or water meter, so as to perform automatic reading and various types of service. With smart meters, various management and control functions are performed whilst ascertaining consumer usage history of electricity, gas or water in real time. Development is accordingly proceeding into meters that have an in-built semiconductor device with a time measurement function that accurately logs times irrespective of the environment in which the meter is installed. Semiconductor devices that have a time measurement function are generally configured to include an oscillator, an oscillation circuit that is connected to the oscillator, and a timer circuit that generates a timing signal of a specific frequency from an output signal of the oscillator. The oscillation circuit and the timer circuit are formed in the semiconductor integrated circuit.

[0006] As a semiconductor device with an oscillator and a semiconductor chip with an oscillation circuit connected to the oscillator in-built in the same package, Japanese Patent Application Laid-Open (JP-A) No. 2009-213061 describes using external terminals provided on an outer face of a vibrator and disposing the vibrator on one face of a wiring board, and disposing a semiconductor chip that is connected to the vibrator to cause it to oscillate disposed on the one face of the wiring board, alongside the vibrator. A resin molding member is then provided on the one face of the wiring board so as to cover the semiconductor chip.

[0007] There is also a circuit device described in JP-A No. 2010-34094 that is equipped with an IC chip that includes an oscillator, and a circuit section that configures an oscillation circuit for electrical connection to the oscillator. In this circuit device, the oscillator has plural electrodes, and there are plural oscillator pads corresponding to the plural electrodes of the IC chip, and the oscillator is electrically connected to the plural oscillator pads on the IC chip by its plural electrodes facing towards the plural oscillator pads on the IC chip through an Anisotropic Conductive Film (ACF).

SUMMARY OF THE INVENTION

[0008] An exemplary aspect of the present disclosure is a semiconductor device that includes: an oscillator; a semiconductor chip that includes an oscillation circuit connected to the oscillator, a timer circuit that generates a timing signal of a frequency according to an oscillation frequency of the oscil-

lation circuit, and a frequency correction section that corrects a frequency of the timing signal based on temperature data; and a discrete device that includes at least one of a temperature sensing device that detects a peripheral temperature, that supplies the detected temperature as temperature data to the frequency correction section, and that is provided as a separate body to the semiconductor chip, or a capacitor that is electrically connected to both the oscillator and the oscillation circuit and that is provided as a separate body to the semiconductor chip, wherein the oscillator, the semiconductor chip and the discrete device are contained within a single package.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Exemplary embodiments of the present invention will be described in detail based on the following figures, wherein:

[0010] FIG. 1 is a perspective view of a configuration of an integrating electricity meter according to a first exemplary embodiment;

[0011] FIG. 2 is a plan view illustrating a configuration of a semiconductor device according to the first exemplary embodiment of the present invention;

[0012] FIG. 3 is a cross-section taken along line 3-3 of FIG. 2;

[0013] FIG. 4 is a perspective view illustrating a configuration of an oscillator according to the first exemplary embodiment of the present invention;

[0014] FIG. 5 is a perspective view illustrating a configuration of a temperature sensing device according to the first exemplary embodiment of the present invention;

[0015] FIG. 6 is a functional block diagram of a semiconductor device according to the first exemplary embodiment of the present invention;

[0016] FIG. 7 is a flow chart illustrating a flow of data storage processing in the first exemplary embodiment of the present invention;

[0017] FIG. 8 is a flow chart illustrating a flow of frequency error derivation processing according to the first exemplary embodiment of the present invention;

[0018] FIG. 9A is a timing chart illustrating operation of a measurement counter and a reference counter in frequency error derivation processing according to an exemplary embodiment of the present invention;

[0019] FIG. 9B is a timing chart illustrating operation of a measurement counter and a reference counter in frequency error derivation processing according to an exemplary embodiment of the present invention;

[0020] FIG. 10 is a flow chart illustrating a flow of frequency correction processing according to the first exemplary embodiment of the present invention;

[0021] FIG. 11 illustrates a relationship between temperature and frequency deviation in an oscillation circuit;

[0022] FIG. 12A is a plan view illustrating a configuration of a semiconductor device according to a second exemplary embodiment of the present invention;

[0023] FIG. 12B is a cross-section taken on 12b-12b of FIG. 12A;

[0024] FIG. 13 is a functional block diagram of a semiconductor device according to a second exemplary embodiment of the present invention;

[0025] FIG. 14 is a perspective view illustrating a configuration of a capacitor according to the second exemplary embodiment of the present invention;