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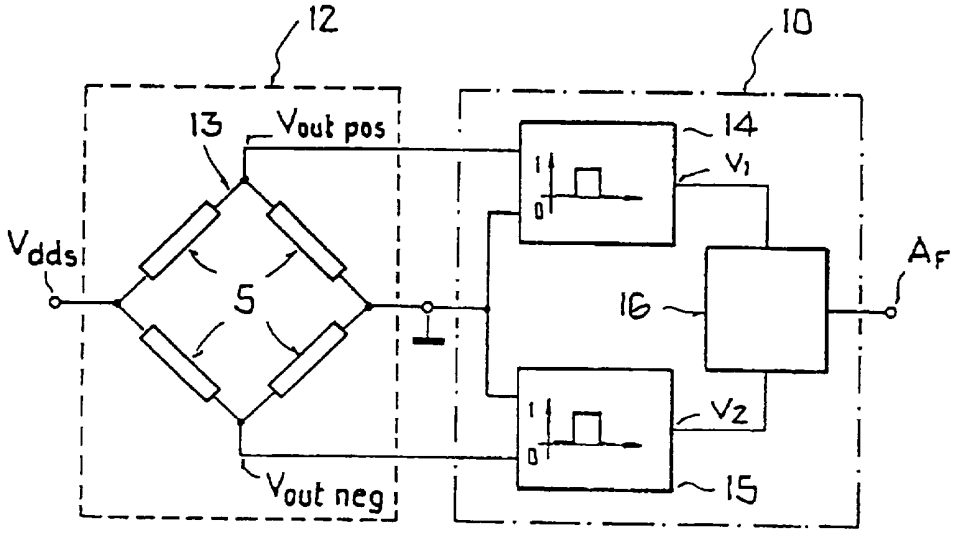
(54) Abstract Title

Monitoring correct operation of a sensor module comprising a Wheatstone bridge circuit

(57) A sensor module consists of a sensor element 12 for detecting a physical quantity, in particular, pressure and acceleration, and at least one integrated circuit 10, wherein at least one Wheatstone bridge 13 producing at least two output signals is arranged on the sensor element. Window comparators 15, 15 are formed in the integrated circuit for producing a fault indication if the output signals exceed or fall below predefined limiting values. Ageing of the wire bond connections, disruptions in the electrical contacts between the sensor element and the signal processing unit or even short circuits due to moisture for example can thereby be recognised and diagnosed as sources of trouble. Furthermore, by using two window comparators simultaneously, each output signal from the Wheatstone bridge is checked and displacements of the bridge level are detected.



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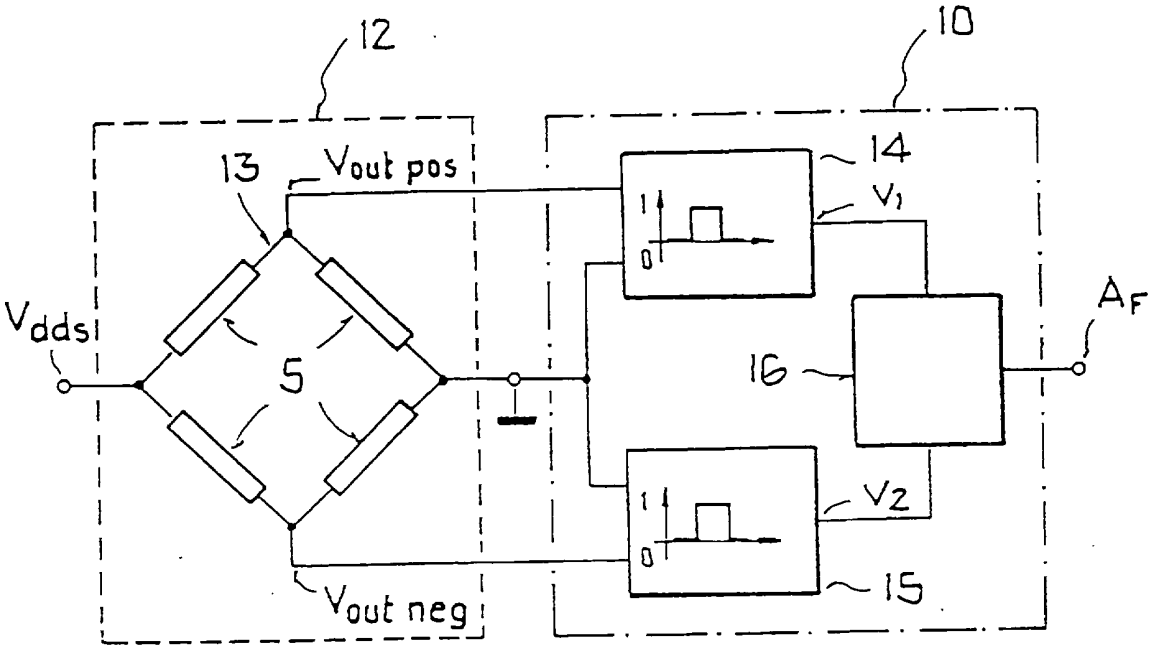

FIG.

SENSOR MODULE

The invention relates to a sensor module consisting of a sensor element for detecting a physical quantity and at least one integrated circuit, wherein at least one test bridge is arranged on the sensor element, said bridge being, in particular, a Wheatstone bridge producing at least two output signals.

Various sensor modules of this type are known. The sensor modules consist of a sensor element and a signal evaluating circuit located on an integrated circuit. The sensor element is, in particular, a piezoelectric, piezoresistive or capacitive acceleration sensor. Such types of sensors for measuring physical quantities such as pressure or acceleration for example consist in turn of a moving part, the so-called seismic mass, and a fixed part. The moving and stationary parts are connected together by means of one or more web members. The deflection of the moving part relative to the stationary part represents a measure for the level of acceleration or the amount of pressure. The mechanical signal - the deflection of the moving part - is thereby converted into an electrical signal. A Wheatstone bridge is arranged on the sensor element for accurately measuring the electrical signal. In this case, the piezoelectric resistances form the resistance elements of the Wheatstone bridge. The output signals of the Wheatstone bridge are passed on to a signal evaluating unit. The signal is evaluated in this signal evaluating unit and processed ready for further use.

Several disadvantages arise here:

- Changes in the bridge level or threshold of the Wheatstone bridge are not taken into account in the case of the piezoresistive sensor elements. The reason for these changes lies in the ageing of the wire bond connections whereby their resistance increases and the voltage drop across these otherwise low resistance connections adopts inadmissible values.
- In addition, disruptions in the electrical contacts due to bonds lifting or
- a low resistance parasitic connection caused by moisture or dirt, especially a short circuit to the supply voltage, are not detected by these sensor modules.

The present invention seeks to overcome or reduce one or more of the disadvantages arising in the case of a sensor module of the type mentioned hereinabove.

According to the present invention there is provided a sensor module consisting of a sensor element for detecting a physical quantity and at least one integrated circuit for evaluating the signals from the sensor, wherein at least one test bridge is arranged on the sensor element to produce at least two output signals (Voutpos, Voutneg), wherein the integrated circuit comprises at least one window comparator which compares at least one output signal (Voutpos, Voutneg) from the test bridge with a defined maximum or minimum value to detect at least one inadmissible bridge level (VPP, VPN) on the test bridge.

Thus, in embodiments of the present invention, at least one integrated circuit comprises at least one window comparator which compares at least one output signal from the test bridge

with a defined, permissible maximum or minimum value whereby inadmissible changes in the bridge levels of the test bridge will be detected. Space can thereby be saved, costs reduced and the functioning of the sensor elements be monitored. Ageing of the wire bond connections, disruptions in the electrical contacts between the sensor element and the signal processing unit or even short circuits due to moisture for example can thereby be recognised in a simple manner.

Advantageous developments arise from an arrangement of at least two window comparators which simultaneously detect and evaluate the two output signals of a Wheatstone bridge. The source of error can thereby be localised even more precisely.

A preferred embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawing which shows a circuit for monitoring the bridge levels.

Four resistors 5 forming a Wheatstone bridge 13 are located on the sensor element 12 in the case of piezoresistive accelerometers or pressure sensors. The main feature of the Wheatstone bridge is that it is very sensitive to even the smallest changes of resistance i.e. small changes in the resistance of the piezoelectric resistances 5 can be measured very precisely. In this embodiment, the four individual resistors are four, theoretically equally large piezoelectric resistances 5 the values of which alter and thereby unbalance the bridge due to the effect of a physical quantity such as e.g. pressure or acceleration. The bridge voltage V_B is proportional to the effective physical quantity such as

pressure or acceleration for example. An inadmissible displacement of the bridge level may thereby occur. Here, the bridge levels VPP and VPN are the voltage drops between the respective output signals V_{outpos} and V_{outneg} and earth. These inadmissible displacements may occur, due to ageing of the wire bond connections, relative to earth or relative to the voltage supply for the sensor element V_{dds}. Here, the voltage V_{dds} is dependent on the operating conditions such as the operating temperature for example. The total resistance increases and the voltage drop in the otherwise low resistance wire bond connections attains inadmissible values.

In addition, the electrical contact to earth, V_{dds}, V_{outpos} and V_{outneg} between the sensor 12 and the integrated circuit 10 may be disrupted, in particular, due to lifting of the bonds. A short circuit caused by moisture is another source of trouble resulting in displacement of the bridge level. The bridge level is permanently monitored by this circuit in order to exclude faults of this type. The output signals V_{outpos} and V_{outneg} of the Wheatstone bridge are supplied to the window comparators 14, 15 and monitored thereby. The switching thresholds are defined as follows:

$$V_1 = \frac{V_{dds}}{2} - T \quad \text{and} \quad V_2 = \frac{V_{dds}}{2} + T$$

The variable T represents the voltage value about which the bridge level may deviate by $V_{dds}/2$ when the arrangement is functioning properly. The voltage values V_1 and V_2 are constantly checked in a second monitoring unit 16. The signal

ONE is present at the output A_F when the bridge level lies within the specified limits V_1 and V_2. In the case of a fault i.e. either V_{outpos} or V_{outneg} or V_{outpos} and V_{outneg} exceed(s) the threshold(s) V_1 or V_2, then the signal ZERO is produced at the output A_F.

Sensor modules of this type may also be equipped with capacitive or other types of test bridge which produce a plurality of output signals.

Claims

1. A sensor module consisting of a sensor element for detecting a physical quantity and at least one integrated circuit for evaluating the signals from the sensor, wherein at least one test bridge is arranged on the sensor element to produce at least two output signals (Voutpos, Voutneg), wherein the integrated circuit comprises at least one window comparator which compares at least one output signal (Voutpos, Voutneg) from the test bridge with a defined maximum or minimum value to detect at least one inadmissible bridge level (VPP, VPN) on the test bridge.

2. A sensor module according to claim 1, wherein the test bridge is a Wheatstone bridge.

3. A sensor module according to claim 1 or 2, wherein at least one integrated circuit comprises at least two window comparators which simultaneously detect and evaluate the two output signals (Voutpos, Voutneg) of a test bridge (13) and thus the bridge level(s) (VPP, VPN) thereof.

4. A sensor module substantially as herein described with reference to the accompanying drawing.

Application No: GB 9901498.7 **Examiner:** Steven Davies
Claims searched: 1-4 **Date of search:** 20 April 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): G1N-NAFD3, NAFD4, NAHK

Int Cl (Ed.6): G01L-27/00 ; G01P-21/00 ; G01R-31/28

Other: Online databases: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	EP 0592205 A1 (NEC) the whole document	1-4

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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