Title: OPTICAL MEASUREMENT SENSOR AND A METHOD FOR EVALUATING A PHYSICAL MAGNITUDE

Abstract: The measurement sensor (2) according to the invention comprises means for transmitting an electromagnetic measurement signal (24, 23a), means for scattering the transmitted electromagnetic signal (21, 21a), means for receiving a scattered electromagnetic measurement signal (24, 23b) and eventually means for evaluating the value of a physical variable to be measured from the received electromagnetic measurement signal. The means for scattering the electromagnetic signal comprise a measurement bar (21, 31) fastened only from its first end, the second end (21a) of which measurement bar is arranged to scatter the electromagnetic measurement signal, the received measurement value of which is proportional to the flexure (f) produced to the measurement bar due to the variable to be measured, and the value of the physical variable to be measured is arranged to be evaluated from the instantaneous flexure experienced by the measurement bar. The measurement sensor according to the invention can be utilized for example in the assay methods for acceleration, vibration, moisture, contact, deflection, magnetic properties and viscosity.
Optical measurement sensor and method for evaluating a physical variable

The invention relates to an optical measurement sensor and a method for evaluating a physical variable with the aid of an optical measurement sensor.

Various measurement sensors can be used in the acceleration or vibration measurement. Acceleration can be measured for example with piezoelectric sensors or sensors based on silica-based solutions.

Also known are acceleration sensors, in which optical elements are used. The published application WO 90/01 169 discloses an acceleration sensor, in which the acceleration moves an object between the optical transmitter and the receiver in one direction. The object is connected to the sensor frame with the aid of a rotating pendulum rod. The location of the object affects the amount of light travelling in the optical circuit. The acceleration experienced by the moving object is evaluated by the amount of light received. The measurement is thus based on the measurement of the amount of light connecting to the detector. The solution disclosed in the reference requires a complex fastening system with an active servo control, thus being big and expensive.

The Japanese published application JP 2000292433 discloses an acceleration sensor, in which the acceleration is measured with a laser beam reflecting from an end of a bar bending in one direction. In the solution, a part of the laser beam travelling in the optical fibre is guided with a grid towards a reflector located in the bar, from which reflector it is reflected back to the grid and the optical fibre. A part of the laser beam is directly reflected back from the grid. The conclusion about the magnitude of the acceleration is made with the aid of the two laser beams. In the apparatus according to the publication, laser and/or optical fibres are needed. Laser is expensive and requires a stabilization circuit. In the fibres, there always occur also power losses in the connection of the luminous efficiency of the source and the detector to the fibre, which losses complicate the measurement process.

US patent 6 263 733 discloses an acceleration sensor based on the light scattering occurring in a medium. In this patent, light is transmitted to a transparent medium. The acceleration experienced by the sensor compresses the medium and affects that way its scattering properties. Thus, the received light scattered from the medium is proportional to the acceleration directed to the sensor. The disclosed measurement method is limited to the measurement of high accelerations.
(5Og) and doesn't therefore as such measure acceleration analogically on a certain sensibility and/or working range.

The Japanese patent publication JP 8297140 discloses an acceleration sensor, in which the acceleration causes light scattering in the optical fibre. In the disclosed solution, the optical fibre is wound around the flexible bar related to the sensor. The acceleration experienced by the sensor bends the bar, due to which also the optical fibre bends. The bending results in increased scattering in the optical fibre. The scattering increases the attenuation of the optical fibre, and in the disclosed solution attenuation is measured. Attenuation is proportional to the acceleration experienced by the sensor. The laser used in the solution requires a stabilization circuit. In the fibres, there always occur also power losses in the connection of the luminous efficiency of the source and the detector to the fibre, which losses complicate the measurement process.

The use of laser increases the price of the acceleration sensor in the above-described solutions.

An aim of the invention is to provide an acceleration sensor, which has a simple and firm mechanical structure. It can either be an independent component or it is assemblage on the circuit board either as a single component or as mountable standard components. Furthermore, the acceleration sensor has low power consumption.

The aims of the invention are achieved with an acceleration sensor, in which a bending measurement bar is used as a measurement sensor. Incoherent light provided by a led is advantageously used for locating the end of the measurement bar. The light emitted by the led scatters from the end of the measurement bar related to the acceleration sensor. The intensity of the scattered light is utilized in the determination of the location of the end of the measurement bar compared to the location of the used receiver. The determined distance difference is proportional to the acceleration directed to the measurement bar, which acceleration can be expressed this way.

An advantage of the sensor according to the invention is that the sensor is suitable, among other things, for measurement of acceleration, vibration and viscosity by an external oscillator.

Further, an advantage of the sensor according to the invention is that it can utilize undirected incoherent light.
Further, an advantage of the sensor according to the invention is that it is based on the diffuse reflection, the sensor thus not being sensible to the angle or the surface material of the reflecting surface.

Furthermore, an advantage of the sensor according to the invention is that accelerations from 1 to 50 g can typically be measured with it.

Further, an advantage of the sensor according to the invention is that the sensitivity and/or measurement range can be changed by the mechanical properties determined by material and dimension selections.

Further, an advantage of the sensor according to the invention is that the sensor can be carried out as a structure, which is directly mountable on the circuit board.

Further, an advantage of the sensor according to the invention is that it works with small operating voltage, in which case for example a 1.5 volt battery can be used as its power source.

Further, an advantage of the sensor according to the invention is that either an analog or digital output is available in it.

Furthermore, an advantage of the sensor according to the invention is that the power consumption of the sensor is low, which allows long service life in solutions, where the sensor is battery or accumulator operated.

The acceleration sensor according to the invention is characterized in that it comprises means for scattering an electromagnetic signal, which means further comprise a mechanical object moving or changing shape due to acceleration, the second end of which object is configured to scatter an electromagnetic measurement signal, the received intensity of which is proportional to the flexure produced to the mechanical object by acceleration, and that the acceleration can be evaluated from the value of the flexure of the mechanical object.

The method for measuring a physical variable according to the invention is characterized in that

- a transmitted electromagnetic measurement signal scatters from the second end of the mechanical object bent by acceleration, brought to move by acceleration or changing shape due to acceleration, and that the instantaneous acceleration is evaluated from the intensity of the received measurement signal scattered from the measurement bar.
Some advantageous embodiments of the invention are presented in the dependent claims.

The basic idea of the invention is the following: the measurement sensor is advantageously based on the flexure of the measurement bar mountable on the circuit board, the measurement bar being supported at least on its first end, when acceleration is directed to the measurement sensor. The magnitude of the flexure is proportional to the acceleration directed to the measurement bar related to the measurement sensor. The flexure is advantageously measured by electromagnetic radiation scattering from the free end of the measurement bar. The used electromagnetic radiation is advantageously incoherent light. The light can advantageously be produced by a led. The light emitting led and the receiver receiving the scattered light are substantially located in the point of the free end of the measurement bar. In this case, the flexure of the measurement bar caused by a physical variable, for example acceleration, to be measured affects the intensity of the scattered light received by the receiver. The flexure of the measurement bar produced by the physical variable can be evaluated by the intensity of the received light. When the mechanical dimensions and mechanical properties of the measurement bar are known, a value for the acceleration, which value has caused the observed flexure of the measurement bar, can be calculated based on the laws of physics. A value of the physical variable to be measured can further be derived from the flexure. A calibration curve describing the physical variable to be measured can be drawn up for each measurement bar using computational or comparison measurement results. In this case, the evaluation of the physical variable can advantageously be made by utilizing the calibration curve of the measurement bar through determination of the acceleration directed to the measurement bar.

In the following, the invention will be described by means of exemplary embodiments. In the description, reference is made to the appended drawings, in which

Fig. 1 shows by way of an example the measurement principle used in the acceleration sensor according to the invention,

Rg. 2a shows by way of an example a measurement sensor arrangement according to the invention seen from the side,
Fig. 2b shows by way of an example an alternative way of fastening of a measurement bar related to the measurement sensor arrangement according to the invention,

Fig. 3a shows a perspective view of the acceleration sensor structure of Fig. 2a,

Fig. 3b shows a perspective view of another acceleration sensor structure according to the invention,

Fig. 4 shows by way of an example one analog measuring circuit used in the acceleration sensor according to the invention,

Fig. 5 shows an example of a characteristic curve of a receiver suitable for the acceleration sensor according to the invention,

Fig. 6 shows by way of an exemplary flow diagram the use of the acceleration sensor according to the invention in the acceleration measurement.

Fig. 7a shows an example of the used pulse ratio, and

Fig. 7b shows an example of an analog output signal to be received from the sensor.

In the following, the structure and the operation of the acceleration sensor according to the invention is described by exemplary embodiments. The invention is, however, not limited to the described exemplary embodiments.

The acceleration sensor according to the invention is based on the optical observation of the mass transition. For example a bar, in which the ratio of the flexure and the force according to Hooke's Law is linear according to formula (1), is used as a mass.

\[
\sigma = E \varepsilon \quad (1),
\]

where \( \sigma \) is tension, \( E \) is modulus of elasticity and \( \varepsilon \) is elongation.

The material of the bar can be for example metal, plastic, silica, ceramics, rubber or composite material.

Acceleration can be calculated according to the Newton's second law, when the mass of the bar and the force needed for the flexure are known.
\[ F = m a \quad (2), \]

where \( F \) is force, \( m \) is mass and \( a \) is acceleration. The force needed for the flexure depends on the loading situation and the cross-section of the bar. The acceleration \( a \) directed to the bar can thus be calculated or evaluated by the mass \( m \) of the bar and the force \( F \) directed to the bar.

Fig. 1 shows an example of the loading situation, in which the measurement bar \( M \) is fastened in its second end in point \( P \) and force \( F \) evenly affects the measurement bar in its entire length. This corresponds to a situation, in which acceleration is directed to the measurement bar \( M \) from the direction of the force \( F \).

The bar \( M \) bends due to the acceleration experienced by it. In the end of the flexure, the bar is bent to the form of \( M' \). The flexure \( f \) of the measurement bar \( M' \) can be derived from the formula (3):

\[ f = \frac{Fl^3}{8EI} \quad (3), \]

where flexure is \( f \), the force produced to the measurement bar by acceleration is \( F \), \( l \) is the length of the bar \( M \), \( E \) is the modulus of elasticity of the material of the bar \( M \) and \( / \) is the moment of inertia. The moment of inertia of the measurement bar of Fig. 1 is calculated from the formula (4).

\[ I = \frac{c^3b}{12} \quad (4), \]

where \( c \) is the thickness of the bar and \( b \) is the width of the bar. The equation of the moment of inertia (4) applies only to the bar having a rectangular cross-section. A formula of the moment of inertia for other cross-sections can be found in the literature of the field.

In the following exemplary embodiments describing the invention, a straight measurement bar \( M \) of uniform width is used in the acceleration sensor. Only the mass of the measurement bar itself is used as a mass in the acceleration calculation. An exemplary measurement bar \( M \) can be made of steel, the thickness of which can be for example 25 \( \mu m \), 50 \( \mu m \) or 100 \( \mu m \). The length of the measurement bar \( M \) can be 28 mm and the width 3.5 mm. In the first end of the measurement bar \( M \), there is advantageously a hole for fastening to the circuit board, and an area is processed to the other, free end of the measurement bar \( M \), which area scatters the optical signal to the receiver.
In an advantageous embodiment of the invention an additional mass is fastened to the free end of the measurement bar M for increasing the flexure f of the measurement bar M.

In an advantageous embodiment of the invention a magnetic component is fastened to the free end of the measurement bar M. In this case, the sensor can be used in magnetic measurements.

In an advantageous embodiment of the invention the measurement bar M consists of moisture-susceptible material. In this embodiment the flexure of the measurement bar indicates an alteration in moisture.

Fig. 2a shows an embodiment of the acceleration sensor 2 according to the invention seen from the side, which embodiment shows an exemplary acceleration sensor as an integrated component assembly. The exemplary measurement bar 21 shown in Fig. 2a advantageously consists of metal. Examples of suitable metals are steel and brass. The length of the measurement bar is advantageously less than 30 mm. The thickness of the measurement bar 21 is advantageously in the range from 20 to 100 µm.

In Fig. 2a, acceleration a, which is indicated with an arrow 28, is directed to an exemplary sensor 2. The exemplary acceleration sensor 2 shown in Fig. 2a comprises an exemplary circuit board 20 or other substrate, an exemplary measurement bar 21, exemplary fastening means 22 and 26 for the measurement bar, an exemplary transmission and receiving circuit 23 and an exemplary analog circuit 24. The sensor can further comprise either a digital or an analog signal processing circuit 25, which can include a pulse control. The transmitter/receiver circuit 23 can be for example a transmitter/receiver pair 23a, 23b operating in the area of visible light or in the infrared area. The transmitter-receiver circuit 23 can be for example a combination of led and light-sensitive detector operating in the infrared area. Also laser is a possible alternative as a transmitter component. The circuit board 20 is advantageously mountable to another circuit board not shown in Fig. 2a by the means according to the prior art.

The sensor according to an embodiment of the invention can be a single component, which is mountable to the circuit board either by cable connection or can be assembled from single standard components to form a part of the circuit board or the like.
In the first end of the measurement bar 21 there is advantageously a hole for fas-
tening the measurement bar 21 to the circuit board 20. A fastening means 26 can advantageously be brought through this hole, which fastening means also pene-
trates through the hole in the supporting component 22. The fastening means 26 thus locks the measurement bar 21 in a stationary manner from its first end to the supporting component 22 and therethrough to the circuit board 20.

The other, free end of the measurement bar 21 advantageously comprises an area 21a, which is processed so that the area is diffusive and scatters the signal coming from the transmitter 23a thereto, which signal can be for example a light pulse or a pulse in the infrared area. The surface treatment can be for example grinding, acid treatment or painting. From the area 21a a signal scatters to the re-
ceiver circuit 23b. The amount of the received scattered light is proportional to the flexure f of the measurement bar 21. The received measurement signal can be amplified in the analog circuit 24. When necessary, also an analog to digital con-
version can be performed to the signal in the processing circuit 25 for evaluating the acceleration data. Said processing circuit 25 is, however, an optional compo-
ent of the sensor 2. If the processing circuit 25 is related to the sensor 2, the ac-
celeration data is thus advantageously evaluated by comparing the received signal to the calibration curve of the measurement bar 21 stored in the memory of the processing circuit 25.

In an advantageous embodiment of the invention, the amplified measurement sig-
nal is taken as an analog signal from the analog circuit 24 to another external cir-
cuit. The amplified analog signal can be used for example as an input signal of an analog measuring instrument or as a signal indicating merely the exceeding of a threshold value.

In Fig. 2b, there is shown another possible way of fastening the measurement bar 21 to the supporting component 22a. In this embodiment, there is a layer of com-
pressible material 27 between the measurement bar 21 and the supporting com-
ponent 22a. The magnitude of the deflection f produced to the measurement bar 21 by the acceleration can be affected by the properties of the material 27. Fur-
thermore, the dynamic properties of the sensor can be affected by the properties of the material 27.

The measurement properties of the acceleration sensor according to the invention can also be altered by altering the mechanical properties of the measurement bar 21.
Figs. 3a and 3b show embodiments of the sensor according to the invention having open structures. The structure according to the invention can also be accomplished as a structure, in which the sensor is enclosed in a manner required by the application.

Fig. 3a shows a perspective view of the acceleration sensor of Fig. 2a. The reference numeral 26 shows a way of fastening the measurement bar 21 by the supporting component 22 to the circuit board 20.

Fig. 3b shows another way of fastening the measurement bar 21 according to the invention to the circuit board 20. In this embodiment, the supporting component is not needed in the sensor 3. The measurement bar 31 is bent to a form, which makes the fastening possible. The first end of the measurement bar 31 is advantageously bent to the form of an angular letter J. The measurement bar 31 is fastened to the circuit board 20 from the shorter arm 32 of the letter J, so that the longer arm of the letter is substantially parallel to the circuit board 20. In other respects, the acceleration sensor advantageously comprises the same components 23, 24 and 25 as the embodiment of the invention according to Fig. 3a.

The acceleration sensor 2 or 3 according to the invention can advantageously be provided with fastening means by the use of which the sensor can, for example, be fastened by an assembly machine to the circuit board or the like of the final application.

The sensor according to Figs. 2a, 2b, 3a and 3b is also suited for the measurement of other magnitudes than acceleration. For example, also vibration can be measured, contact can be detected, displacement, moisture, magnetic properties or viscosity of a substance can be measured with the sensor 2 or 3 by using an external oscillator.

Fig. 4 shows an exemplary circuit switching, which can be used in the acceleration sensor 2 or 3 according to the invention. For example, the analog circuit 24 shown in Fig. 2a can be accomplished with the circuit switching shown in Fig. 4. The reference numeral 23 refers to an IR transmitter/receiver. A suitable transmitter/receiver pair is OMRON EE-SY1 93.

The reference numeral 24 indicates analog electronics advantageously related to the transmitter/receiver. It comprises resistances Ri to Re, operation amplifiers Ai and A2 as well as a transistor Q1. Low operating voltage U (from 1 to 5 V) and low power consumption are the starting points in the planning of peripheral electronics
of the sensor. Also the number of components has been kept low, in which case it has been managed to keep the size and price of the analog circuit small.

If the acceleration sensor according to the invention is integrated as a part of another circuit board, the analog electronics can be accomplished as a part of said other circuit board. In this case, the analog components need not necessarily be a part of the acceleration sensor component according to the invention.

A constant current source, which has been accomplished with the transistor Qi and operation amplifier Ai, is used for controlling the IR led (Fig. 2a, reference numeral 23a). The current source is advantageously controlled by an outer input Mod. The control can either be a direct voltage or a pulse-like signal. With the direct voltage the transistor Qi can be brought to a state, where the IR led (Fig. 2a, reference numeral 23a) emits constantly. The emitting incoherent infrared light is shown with reference L1. The control signal can either come from the processing circuit 25 of the acceleration sensor 2 or from an external source of the acceleration sensor.

The state of the transistor Qi can be changed between the conducting and the non-conducting state by using a pulse-like control signal. Consequently, also the IR led transmits IR pulses in the Mod frequency of the control signal.

The received scattered signal Ls controls the light-sensitive transistor 23b in the transmitter/receiver circuit 23. The light flux produced by the received signal is measured over the resistance R4 and amplified by a direct voltage amplifier A2.

In the described connection, it is advantageous to use operation amplifiers, which operate in the operating voltage from 1 V to 5.5 V and the current consumption of which is about 15 μA.

With the connection shown, the pulse ratio being 1:100, a current consumption of less than 100 μA can be achieved in the acceleration measurement. This enables a continuous service life of 500 days with an ordinary 1.5 V AAA size alkaline battery (1200 mAh) and of 3 years with an AA size alkaline battery (2700 mAh).

An A/D converter of the measurement signal and a processing circuit 25 of the digital signal are not shown in Fig. 4. It is, however, obvious to a person skilled in the art that the amplified analog signal must be converted to digital, if it is desired to be transmitted for example to the processing circuit 25 for acceleration calculation.
The circuit arrangement of Fig. 4 also enables to transmit the output of the voltage amplifier \( A_2 \) as an analog signal to an external device. The signal can be used, for example, for producing light, sound or vibration.

The exemplary processing circuit 25 of Figs. 2a and 3a advantageously comprises a processor according to the prior art and appropriate memory. The calculation formulas (1) to (4) necessary for the acceleration calculation are advantageously stored in the memory. Further, the dimension and material data of the measurement bar to be used in the measurement and the planned resting distance between the measurement bar 21 and the transmitter/receiver circuit 23 can be stored in the memory. Also calibration data calculated or evaluated for the used measurement bar can be stored in the memory. In this case, the acceleration value can be obtained in the measurement process by comparing the measured signal proportional to the acceleration with the calibration data stored in the memory. It is also advantageous to store the response curve of the used IR transmitter/receiver in said memory, which curve is used for the determination of the location of the bending end of the measurement bar.

Fig. 5 shows the properties of the exemplary circuit OMRON EE-SY193 used in Fig. 4 in relation to the distance measurement. The transmitter of the component is an IR led \((\lambda = 940 \text{ nm})\) and the receiver is a Si phototransistor. The component is specified to the 4 mA current of the led, in which case the threshold voltage of the led is typically about 1.1 V, the light flux current of the transistor is 150 \( \mu \text{A} \) and the rise and fall times are 25 \( \mu \text{s} \) and 30 \( \mu \text{s} \) for the load of 1 k\( \Omega \). In Fig. 5, the phototransistor current of the receiver is typically in its maximum as a function of distance \( d \). In the acceleration sensor 2 according to the invention the measurement bar 21 is advantageously located in the middle of the rising edge of the curve shown in Fig. 5, in which case the measurement range of the sensor 2 in the flexure measurement is about \( \pm 100 \mu \text{m} \).

Fig. 6 shows as an exemplary flow diagram the use of a sensor according to the invention in the measurement of a physical variable. The measurement of a physical variable is based on the measurement of acceleration experienced by the sensor. Also the characteristics of the acceleration sensor according to the invention shown in Figs. 2a to 5 are used as a help in the description. The measurement is started in stage 60a. In stage 61, the amplifier of the sensor 2 is switched on. In stage 62, the transmitter and the receiver of the sensor 2 are switched on.

After this in stage 63, it is waited that the transmitter and the receiver are settled to
the operation mode. A LED 23a operating in the infrared area can advantageously be used as a transmitter. A photosensitive transistor circuitry can advantageously be used as a receiver.

The transmitted light scatters from the free end of the measurement bar 21, 31, the distance of the free end to the receiver 23b of the transmitter and receiver circuit 23 depending on the direction and the magnitude of the acceleration directed to the measurement bar.

In stage 64, a value of the signal received from the receiver is read, which value is proportional to the distance of the bent second end (21a) of the measurement bar to the receiver (23b). After this, the transmitter and the receiver are switched off in stage 65.

In stage 66, the received value of the signal is converted to the initial value of the physical variable to be measured.

In stage 67, the converted initial value of the physical variable is set to the output port of the sensor 2. The signal to be set to the output port can either be an analog signal or a digital signal. From the output port, the signal can either be transmitted to another separate device or to a processing circuit 25 related to the sensor 2. Fig. 7b shows an example of three possible analog output signals.

If the measured signal is transmitted to the processing circuit 25, the signal of the output port is A/D-converted in an optional processing circuit 25. In this case, the received measurement signal can be compared to the calibration curve in the memory of the processing circuit 25, with the aid of which the flexure value can be converted to a value of the physical variable to be measured, for example to the value of acceleration. Alternatively, with the dimension and material data available, it is also possible to calculate first the location of the end of the measurement bar and after that the value of the physical variable corresponding to the calculated location. The acceleration value determined by the processing circuit 25 can be, for example, the average value, peak value or the continuous value of the acceleration in a specific time interval.

The processing circuit 25 can advantageously determine or calculate also other values describing the vibration experienced by the acceleration sensor, i.e. identify contact in the acceleration sensor, determine magnetic properties of the environment or conclude the beginning or ending of a state of motion of a device connected to the acceleration sensor.
In stage 68, a decision is made, whether a new measurement is needed, in which case it is returned back to stage 62 through delay 69, or whether the acceleration measurement is ended in stage 60b. The delay 69 can be chosen according to the application.

Fig. 7a shows an example of a pulse ratio, which can be used. In the example, the transmitter is activated to transmit a 50 µs pulse at the interval of 5 ms. In this case, the obtained pulse ratio is 1:100. This kind of pulse ratio can be obtained with the delay element 69 shown in Fig. 6. The power consumption of the sensor 2 and thereby its service life can be affected by the selection of the pulse ratio when using batteries.

Fig. 7b shows an example of the analog output signal of the sensor 2. The output signal can either be a continuous analog signal 71, a uniformly sampled signal 72 or a signal 73 indicating the peak value of the signal.

Some advantageous embodiments of the acceleration sensor according to the invention and the measurement method related to it have been described above. The invention is not limited to the solutions described above, but the inventive idea can be applied in numerous ways within the scope of the claims.
Claims

1. An acceleration sensor (2, 3) comprising
- means for transmitting an electromagnetic measurement signal (24, 23a)
- means for scattering the transmitted electromagnetic signal (21, 21a)
- means for receiving the scattered electromagnetic measurement signal (24, 23b),

characterized in that the means for scattering the electromagnetic signal comprise a mechanical object (21, 31) moving or changing shape due to acceleration, a second end (21a) of which is configured to scatter the electromagnetic measurement signal, the received intensity of which is proportional to the flexure (f) produced to the mechanical object (21, 31) by acceleration, and that an acceleration can be evaluated from the flexure (f) of the mechanical object.

2. The acceleration sensor according to claim 1, characterized in that said mechanical object is a measurement bar (21, 31).

3. The acceleration sensor according to claim 2, characterized in that a measured acceleration value is configured to be evaluated by comparing the measurement values of the received signal and a calibration curve of the measurement bar (21, 31).

4. The acceleration sensor according to claim 2, characterized in that a measurement range and a measurement sensitivity of the physical variable to be measured are configured to be evaluated by dimensions and a material of the measurement bar (21, 31).

5. The acceleration sensor according to claim 1, characterized in that the means for transmitting an electromagnetic measurement signal comprise a light transmitter (23a).

6. The acceleration sensor according to claim 5, characterized in that the light transmitter (23a) is configured to transmit light pulses.

7. The acceleration sensor according to claim 1, characterized in that the means for receiving the electromagnetic measurement signal comprise a light receiver (23b).

8. The acceleration sensor according to claims 5 to 7, characterized in that the light used is incoherent infrared light.
9. The acceleration sensor according to claim 8, characterized in that the infrared transmitter (23a) and the infrared receiver (23b) are integrated in the same component.

10. The acceleration sensor according to claim 9, characterized in that it further comprises an analog amplifier (A₂) and an analog output related to it.

11. The acceleration sensor according to claim 10, characterized in that it further comprises an analog-digital converter and a digital signal processing circuit (25) for evaluating the numerical value of the variable to be measured.

12. The acceleration sensor according to claims 1 to 11, characterized in that the acceleration sensor (2, 3) comprises connection means for connecting it by assembling to another component.

13. The acceleration sensor according to claims 1 to 11, characterized in that the acceleration sensor comprises a circuit board (20), to which the infrared transmitter (23a), the infrared receiver (23b), the analog circuit (24) and the measurement bar (21) are connected.

14. The acceleration sensor according to claim 13, characterized in that it further comprises the signal processing circuit (25).

15. The acceleration sensor according to claim 13 or 14, characterized in that the circuit board (20) comprises means for connecting the measurement sensor (2, 3) to another circuit board.

16. A method for measuring acceleration, in which method:
- an electromagnetic measurement signal (62, 63) is transmitted
- an electromagnetic measurement signal (64) is received
- instantaneous value of the physical variable is evaluated from the received electromagnetic measurement signal (66), characterized in that
  - the transmitted electromagnetic measurement signal scatters from a second end (21a) of a mechanical object (21) bent by acceleration, brought to move by acceleration or changing shape due to acceleration, and that
  - an instantaneous acceleration is evaluated from the intensity of the received measurement signal scattered from the measurement bar.
17. The method according to claim 16, characterized in that the acceleration value is evaluated by comparing the value of the received acceleration signal with a known calibration data.

18. The method according to claim 17, characterized in that incoherent infrared light is used as the electromagnetic signal.

19. The method according to claim 18, characterized in that the infrared light is transmitted in pulses.
Fig. 4

Sensing Distance Characteristics (Typical)

Fig. 5
Starting the measurement

Switching on the amplifier

Switching on the transmitter/receiver

Waiting the settling time

Reading the value of the sensor

Switching off the transmitter/receiver

Converting the received signal to initial value

Entering the initial value to the output port

Yes

New measurement?

No

Measurement completed

Fig. 6
**INTERNATIONAL SEARCH REPORT**

International application No

PCT/FI2009/050285

A CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC: G01P, G01D, G01L, G01H, G01S, G01B, GOU

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

FI, SE, NO, DK

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

EPO-Internal, WPI, INSPEC, XPAIP, XPIEE, XPESP, XPRED, XPI3E, XPIOP

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tbody>
<tr>
<td>X</td>
<td>US 5207766 A (CONFORTI GIULIANO et al.) 04 May 1993 (04.05.1993), col. 4, line 50 - col. 5, line 19; col 11, lines 18-39; col. 7, lines 11-63; col. 10, lines 10-20; col. 11, lines 18-39; claims 7, 13; figs. 1, 4, 5, 7.</td>
<td>1-19</td>
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<td>A</td>
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<td>JP 2002162213 A (NIPPON CERAMIC KK) 07 June 2002 (07.06.2002), EPDOC and WPI abstracts; JPO English machine translation: paragraphs [0001], [0011] - [0022]; figs. 1-4.</td>
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<td>JP 9257827 A (YAMAHA CORP) 03 October 1997 (03.10.1997), JPO English machine translation: paragraphs [0019], [0028] - [0030], [0038] - [0042]; figs 1, 4, 6</td>
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<td>A</td>
<td>US 6525307 B1 (EVANS III BOYD M et al) 25 February 2003 (25.02.2003), abstract; col.3, line 66 - col. 14, line 16; figs. 1, 2</td>
<td>1-19</td>
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Further documents are listed in the continuation of Box C.

See patent family annex

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Date of the actual completion of the international search

26 June 2009 (26 06 2009)

Date of mailing of the international search report

02 July 2009 (02 07.2009)

Name and mailing address of the ISA/FI

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