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(54) **Method for detecting rotation of a dishwasher spray arm**

(57) A method for detecting rotation of a dishwasher spray arm, wherein the method comprises:
(a) detecting vibrations generated during operation of the dishwasher;
(b) comparing the level of the detected vibrations with a predetermined threshold, and increasing a count value in dependency of whether the level of the detected vibrations exceeds the predetermined threshold;
(c) comparing the count value that is obtained for a predetermined period of time with a predetermined target range; and
(d) determining that there is a disturbance in the rotation of the spray arm, when the count value is outside the predetermined target range.

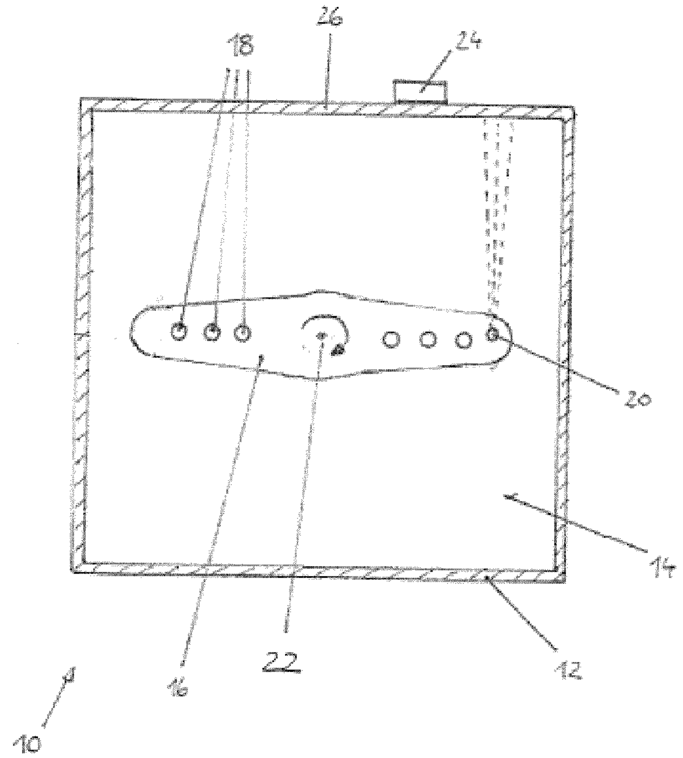

FIG. 1

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Description

[0001] The present invention relates to a method for detecting rotation of a dishwasher spray arm and a dishwasher adapted to perform such a method.

[0002] In the prior art several attempts were made to provide in a dishwasher means to detect whether during operation of the dishwasher a spray arm rotates as intended, so as to detect a faulty operation in which, for example, the spray arm is blocked by articles that were placed into the washing tub to be cleaned but which intercept with the path of movement of the spray arm.

[0003] Thus, for example in DE-A-40 100 66 there is described a dishwasher in which a microphone is used to detect the sound pattern created by the water jets emitted during operation of the dishwasher and wherein a frequency spectrum analysis of the signal generated by the microphone is performed. To this end, in the system of DE-A-40 100 66 a plurality of bandpass filters is provided which are designed around specific predetermined frequency bands that are characteristic for the sound pattern caused by the rotating spray arms.

[0004] A similar detection method is suggested in WO-A-02/060606, wherein sound signals are picked up at the exterior of the dishwasher vessel, and wherein certain properties of these signals, such as sound pressure levels, amplitude variations, spectral content, and rotational information are extracted and analyzed against reference parameters.

[0005] A further method for monitoring proper operation of a dishwasher is described in DE-A-102 04 455 wherein it is suggested to record typical sound patterns that are created during operation of a dishwasher and to compare such sound patterns with a plurality of previously stored typical sound patterns which are recorded in advance for various components of the dishwasher, such as the drain pump, the circulation pump, the detergent dispenser and the spray arms. By determining whether an instantaneous sound pattern can be regarded as similar to any of the pre-stored sound patterns, it thus shall be possible to conclude whether the spray arms operate properly.

[0006] The mayor drawback with this kind of detecting sound patterns is that a frequency spectrum analysis involves quite complicated signal processing algorithms which cannot be easily implemented and handled by common microprocessors, which is particularly the case if also the function of the bandpass filters shall be performed by the microprocessor. For this reason, if possible, hardware filters are used instead of digital ones. However, the main drawback in using hardware filters is on the one hand that they have involve additional costs and on the other hand that they are not configurable in the sense that they have fixed characteristics and hence it is not possible to provide for an end-of-production tuning and/or calibration. While there exist also some configurable hardware filters, the costs of these filters are prohibitive for use in white goods.

[0007] It is an object of the present invention to provide for a method for detecting rotation of a dishwasher spray arm that is less complicated than the prior art systems and which thus can implemented at relatively low costs.

[0008] In accordance with the present invention this object is solved by the method for detecting rotation of a dishwasher spray arm as it is defined in claim 1, which method comprises:

(a) detecting vibrations generated during operation of the dishwasher;

(b) comparing the level of the detected vibrations with a predetermined threshold, and increasing a count value in dependency of whether the level of the detected vibrations exceeds the predetermined threshold;

(c) comparing the count value that is obtained for a predetermined period of time with a predetermined target range; and

(d) determining that there is a disturbance in the rotation of the spray arm, when the count value is outside the predetermined target range.

[0009] In contrast to prior art methods which rely on frequency analysis of the detected sound pattern and which therefore require a rather sophisticated means for processing the detected signals, the method suggested herein makes use of the fact that for any dishwasher the rotating speed of the unblocked spray arm is a design parameter which anyway is known or can be easily determined and which thus can be used as basis to predict the number of peaks in a vibration signal detected during operation of the dishwasher. Thus, taking into account that dishwasher spray arms usually are driven by driving nozzles that direct a water jet at an angle to the axis of rotation of the spray arm, such as radially in the plane of rotation of the spray arm, the water j et emitted by such a driving nozzle will periodically hit the walls of the washing tub of the dishwasher, where due to the impact of the water jet vibrations will be generated which can be reliably detected by a vibration sensor. Hence, if during normal, unblocked operation the spray arm rotates with a rotational speed of for example 30 rpm, a vibration sensor that is located to pick up a vibration signal at one of the sidewalls of the tub can be expected to pick up a corresponding number of peaks that stand out from the vibratory signal level detected during the remainder of the revolution of the spray arm. In this manner the number of revolutions of the spray arm can be reliably detected. Should the count value of detected vibration peaks within a given period of time largely differ from a predetermined standard value, it thus can be determined that the spray arm is blocked or rotates at a speed that is outside the intended range.

[0010] In particular, should the count value of detected vibration peaks within a given time period be lower than an expected minimum value, then the rotation of the spray arm probably is blocked at a location that is remote from the sensor, so that the sensor does not pick up the vibration signal caused by the water jet of the non-rotating spray arm. On the other hand, if a large number of peaks is detected, then it can be assumed that the spray arm is blocked in a rotary orientation where a water jet emitted from one of the driving nozzles hits the dishwasher tub at a location where the vibrations caused by the impact of the water jet are constantly or repeatedly picked up by the sensor.

[0011] By counting peaks in the vibration signal detected during operation of the dishwasher, apart from determining a blocking of the rotation of the spray arm, also other faulty operational states of the spray arm can be detected. In particular, it further can be determined that the spray arm rotates, however, at a speed that is lower than the design speed, when the count value is within a predetermined range that is lower than the predetermined target range. Such a rotation of the spray arm at a lower speed can be indicative for a situation in which dirt particles that were contained within the washing liquor circulated through the dishwasher have accumulated within the spray arm and thus block the water feed to the driving nozzle(s). In dishwashers wherein there is more than one spray arm, a blockage of the water feed to one spray arm further may result in an increase of the water feed to another spray arm. Hence, if the evaluation of the count value indicates that the count value is within a predetermined range that is higher than the predetermined target range for normal operation, then it can be determined that the spray arm rotates, however, at a speed that is higher than the design speed, which can be indicative for a blockage of the water feed to a different spray arm than that for which the evaluation of the count value is performed.

[0012] In making the determination whether the level of the detected vibrations is above a predetermined threshold, the threshold should be set at a level that provides for a high confidentiality that the picked up signal is representative for a vibration peak caused by the passing water jet, such as by selecting for such threshold a signal level which corresponds to about half the expected maximum signal level.

[0013] Similarly, while it is advantageous to detect a blocking of the rotation of the spray arm soon after occurrence of the blockage, the predetermined period of time within which the count value is compared with a predetermined target range should not be set too short, so as to be able to provide for a statistically relevant evaluation of the comparison. Considering that a dishwasher spray arm typically rotates at speeds of about 25 to 45 rpm, setting the predetermined period of time within which the count is made to one minute usually provides for reliable results. Of course, if more precise values are envisaged, longer periods could be selected.

[0014] Once a faulty operation of the spray arm is detected, a warning message, such as an optic or acoustic signal, can be issued to alert the user of the washing machine, so that the user can check on the proper operation of the spray arm so as to avoid the washing cycle to be carried out inefficiently. Additionally or alternatively the respective washing cycle can be automatically interrupted or terminated to be continued only after intervention by the user.

[0015] Preferred embodiments of the present invention are defined in the dependent claims.

[0016] In particular, the method can be designed such that in step (b) the count value is increased only if the level of the detected vibrations exceeds the predetermined threshold for a predetermined duration of time, so as to avoid that incidental short term signal peaks which do not correlate with the rotation of the spray arm erroneously are interpreted to be indicative for a rotation of the spray arm.

[0017] In addition or alternatively, step (b) further can comprise, upon increasing the count value, waiting for a predetermined sampling period and then further increasing the count value if the level of the detected vibrations exceeds the predetermined threshold, wherein the sampling period preferably is determined based on a target frequency of rotation of the spray arm. In this manner it can be taken into account that a regular peak that is indicative for a rotation of the spray arm usually creates a signal peak of a certain length. That is, in a dishwasher wherein the spray arm during normal unblocked operation rotates at a speed of 38 rpm, the spray arm thus needs a period of $T = \frac{60s}{38} = 1.6s$ per rotation. Assuming that the vibration sensor is located at one of the side walls of a tub of square cross section and further assuming that the vibration sensor picks up a corresponding peak signal as long as the water jet causing the vibrations impinges onto the wall where the vibration sensor is located, a regular vibration peak will have a duration of at most $\frac{1.6s}{4} = 0.4s.$ Hence, once a signal peak has been detected and therefore the count value has been increased, any peak that is detected within a period that is shorter than a sampling period of 0.4s can be ignored as an obviously false signal.

[0018] In case that the method employs a vibration sensor which provides a voltage signal, such signal can be converted into a logic signal, such as by an A/D converter, which in preferred embodiments can be implemented by a transistor-transistor logic (TTL) which thus converts the voltage signal into a corresponding TTL signal, which then can be further processed in a microprocessor.

[0019] In preferred embodiments a root mean square (RMS) value is determined from a plurality of measurements performed in step (a), wherein the thus obtained root mean square (RMS) value then is used in step (b) as level of the detected vibrations. In this manner, reliability of the detection of the spray arm rotation can be further increased.

[0020] In a further aspect, the present invention is a dishwasher adapted to carry out the above process, and in particular a dishwasher comprising a washing tub for accommodating articles to be cleaned, at least one spray arm arranged within the washing tub for directing a cleaning fluid to the articles to be cleaned, and a vibration sensor for detecting vibrations generated during operation of the dishwasher, wherein the dishwasher further comprises means for detecting rotation of the spray arm which means is adapted to carry out the process described above.

[0021] In preferred embodiments the vibration sensor comprises a piezoelectric shock sensor. A piezoelectric shock sensor produces a voltage output signal that is substantially proportional to the acceleration of the sensor caused by a mechanical vibration of the sensor, i.e. an output signal that is substantially proportional to impacts or vibrations to which the sensor is exposed.

[0022] Preferably the vibration sensor is attached to the exterior side of the tub so that the sensor is located outside the wet zone of the dishwasher. In this manner it is not necessary to take any specific precautions to avoid contact of electrically driven sensor components with the cleaning liquid that is circulated through the dishwasher tub.

[0023] A preferred location for the vibration sensor is at a side wall of the tub. When the spray arm comprises at least one driving nozzle for emitting a water jet at an angle to the axis of rotation of the spray arm, the vibration sensor preferably is attached to a side wall of the tub at about the level where the water jet emitted from the driving nozzle hits the side wall of the tub, so that the excitation of the vibration sensor by the passing water jet is at a maximum.

[0024] In order to provide for a substantially attenuation-free transmission of the vibratory signal from the sidewall of the tub where the signal is generated by impingement of a water jet onto the sidewall to the vibration sensor, the vibration sensor preferably is attached to the exterior side of the tub by a substantially rigid connection, such as by gluing the vibration sensor directly to the exterior side of the tub.

[0025] It should be understood that the method described herein can be applied to detect rotation of any dishwasher spray arm, irrespective of whether such spray arm is part of a dishwasher having a single spray arm or is provided in a dishwasher having a plurality of spray arms. In case that rotation of more than one spray shall be monitored, this can be done by the use of a single vibration sensor, provided that measures are taken to assign the detected vibrations to the individual spray arms during evaluation of the signal. In monitoring a plurality of spray arms, the processing of the sensor signals can be facilitated and at the same time made more reliable, if for each spray arm at least one individual vibration sensor is provided at a location where the respective spray arm causes vibrations at the tub, wherein additional measures can be taken to separate the vibration signals caused by the individual spray arms, such as by providing dampening elements at the exterior side of the tub so as to avoid that the vibration sensors pick up vibrations of comparative magnitude from more than one spray arm. Thus, for example in a dishwasher having a lower spray arm and an upper spray arm, the vibrations caused by the lower spray arm could be picked up at one of the side walls of the tub, for example at the left side wall, wherein in the upper part of such side wall there are provided dampening elements, such as additional fixations, so as to avoid or dampen any vibrations that are caused by the upper spray arm. Correspondingly, rotation of the upper spray arm could be monitored by picking up vibrations caused by the upper spray arm at a different side wall of the tub, for example at the right tub wall, wherein dampening elements are provided in the lower part of such side wall, so as to avoid or dampen any vibrations that might be caused at the right tub wall due to water jets originating from the lower spray arm.

[0026] A preferred embodiment of the method of the present invention is explained below by reference to the drawings in which:

FIG. 1 is a cross sectional view of a dishwasher in which a vibration sensor is provided to detect vibrations generated during operation of the dishwasher, and wherein means are provided to determine, based on the signal provided by the vibration sensor, whether the spray arm is in unblocked rotation;

FIG. 2 shows the voltage signal provided by the vibration sensor of FIG. 1 during normal rotation of the spray arm;

FIG. 3 shows the signal of FIG. 1 when rectified;

FIG. 4 shows a counter trigger signal derived from the signal shown in FIG. 3;

FIG. 5 shows the voltage signal provided by the vibration sensor of FIG. 1 when rotation of the spray arm is blocked close to the sensor, i.e. when the sensor constantly picks up a vibration signal;

FIG. 6 shows a counter trigger signal derived from the signal shown in FIG. 5;

FIG. 7 shows the voltage signal provided by the vibration sensor of FIG. 1 when rotation of the spray arm is blocked remote from the sensor, i.e. when the sensor does not pick up a strong vibration signal;

FIG. 8 shows a counter trigger signal derived from the signal shown in FIG. 7;

FIG. 9 shows the result of a root mean square (RMS) routine derived during normal rotation of the spray arm;

FIG. 10 shows the result of a root mean square (RMS) routine derived when rotation of the spray arm is blocked far from the sensor; and

FIG. 11 shows the result of a root mean square (RMS) routine derived when rotation of the spray arm is blocked close to the sensor.

[0027] In FIG. 1 there is shown a schematic cross-sectional view of the tub of a dishwasher 10 made in accordance with the teachings of the present invention. Dishwasher 10 comprises a tub 12 within which articles to be cleaned are accommodated during a washing cycle. At the floor 14 of tub 12 there is provided a spray arm 16 having a plurality of spraying nozzles 18 via which a cleaning fluid can be sprayed upwardly towards the goods to be cleaned. Towards its lateral ends spray arm 16 is provided with a driving nozzle 20 which is designed to eject a water jet at an angle to the axis 22 of rotation of the spray arm 16. In the embodiment shown in FIG. 1, driving nozzle 20 is designed to eject a water jet radially from the spray arm 16 substantially in the plane of rotation of spray arm 16. Due to reaction forces of the water jet ejected from the driving nozzle 20 spray arm 16 is caused to rotate in FIG. 1 in the clockwise direction, as shown in FIG. 1 by an arrow of rotation indicated about axis 22.

[0028] Thus, during rotation of spray arm 16 as shown in FIG. 1 also the location where the jet emitted from driving nozzle 20 impinges onto the sidewalls of tub 12 travels along the sidewalls of the tub in the clockwise direction. In order to detect the vibrations caused by the impingement of the jet from driving nozzle 20 there is provided a vibration sensor 24 which is attached to the exterior side of the tub 12 and which in the embodiment shown in FIG. 1 is glued onto the exterior side of sidewall 26 at a level which corresponds to the level where the jet ejected from driving nozzle 20 impinges the sidewalls of tub 12. However, it should be understood that since the vibrations caused by the impingement of the jet from driving nozzle 20 onto the sidewalls of the tub 12 propagate from the location of impingement towards the edges of the sidewalls, the vibration sensor need not be located exactly at the level of impingement. Rather, the vibration sensor 24 also can be placed offset from the level of impingement and/or from the center of the sidewalls, as it is shown in FIG. 1.

[0029] FIG. 2 shows a typical example of a voltage signal generated by vibration sensor 24 during normal, unblocked rotation of the spray arm 16. In the example shown in FIG. 2 the vibration sensor 24 outputs a signal having a distinct peak every time the water jet emitted from driving nozzle 20 hits the sidewall 26 of tub 12 at which the vibration sensor 24 is located. In the example shown in FIG. 2, the spray arm 16 rotates at a speed of about 38 rpm, so that between each two adjacent peaks there is a time span of about 1.6 seconds.

[0030] To facilitate processing of the output signal from sensor 24, the output signal first is rectified, so that a signal curve is obtained as it is shown in FIG. 3.

[0031] In order to avoid that incident signal peaks are interpreted as a vibration signal that is caused by the water jet from driving nozzle 20 passing by, i.e. as a rotation of spray arm 16, only those peaks in the output signal of vibration sensor 24 are considered which on the one hand are of a certain magnitude as it is depicted in FIG. 3 as threshold voltage V_T, and which on the other hand are of a certain duration, such as 0.1 seconds. Any peak that fulfills these criterions causes a counter trigger to generate a trigger signal as it is depicted in FIG. 4. In order to determine whether spray arm 16 is rotating regularly, a count value which is obtained for a predetermined period of time is compared with a predetermined target range.

[0032] In the above example where spray arm 16 rotates at a design speed of 38 rpm, the target range determined during a one-minute period could be selected for example as 35 to 40, so as to take into account that spray arm 16 is driven with water that is circulated within the washing tub, i.e. with cleaning water which during a washing process is collected in the sump of the tub and which is fed via a circulation pump to spray arm 16. Since such water thus inevitably will contain dirt particles that have been washed off articles to be cleaned within the washing tub, the water fed to driving nozzle 20 will be subject to certain variations. Furthermore, rotation of the spray arm 16 can repeatedly be decelerated or accelerated by reaction forces caused by water jets that are emitted from any of the spray nozzles 18 and which impinge onto articles to be cleaned within the washing tub.

[0033] FIG. 5 shows the voltage signal received from the output of vibration sensor 24 when the rotation of spray arm 16 is blocked, for example because one of the articles to be cleaned has been dislocated during the washing process and coincides with the path of rotation of the spray arm 16. FIG. 5 shows a situation where the spray arm 16 is blocked in an orientation in which the water jet ejected from driving nozzle 20 constantly impinges onto sidewall 26 where the vibration sensor 24 is attached, so that the vibration sensor 24 permanently generates a high output signal.

[0034] FIG. 6 shows the corresponding counter trigger signal. In the example shown in FIG. 6 a sampling period of 0.4 seconds has been selected, so that the count value of the counter is increased every 0.4 seconds. Based on the fact that within the predetermined time period thus a count number is reached which will be outside the predetermined range, the system will determine that the spray arm apparently is blocked. Based upon this determination, an optic or acoustic warning message can be issued to the user to check on the status of the spray arm. Since for removal of an obstruction that impedes rotation of the spray arm the operation of the dishwasher has to be interrupted, the system also can be designed to automatically interrupt a washing cycle in case that it is determined that the spray arm does not rotate as intended.

[0035] In FIG. 7 there is shown a typical example of the output of vibration sensor 24 as recorded in a situation when rotation of the spray arm is blocked in an orientation in which the water jet emitted from driving nozzle 20 impinges onto the wall of tub 12 at a location that is remote from vibration sensor 24. In such a situation, the sensor will deliver an output signal that does not exhibit any clearly distinct peaks and which further constantly remains below the threshold voltage V_T. Therefore, the counter trigger signal will constantly remain at zero, as it is depicted in FIG. 8 so that within the predetermined time period the counter value will not reach the predetermined target range. Hence, similarly as was the case explained above by reference to Figs. 5 and 6, the system will issue a warning message to the user and optionally will interrupt operation of the dishwasher, so as to give the user the opportunity to check on the state of the spray arm to then continue the washing process.

[0036] In the above manner it is avoided that, due to the rotation of the spray arm being blocked, a washing cycle is performed in which a satisfactory cleaning result only is achieved for a small portion of the goods to be cleaned, namely those articles that are located above the blocked spray arm, whereas the remaining goods are not exposed to a sufficient amount of cleaning liquid to satisfactorily wash off any debris adhering to such articles.

[0037] In accordance with the present invention the proper rotation of the spray arm thus can be reliably determined, basically by counting the peaks of the signal received from the vibration sensor and comparing the peak count with an expected value which is a design parameter for the specific dishwasher. While there may be situations wherein a signal peak is generated which is not directly associated to a rotation of the spray arm but which may be caused for example by an incidental impact of water jets that are reflected from articles within the dishwasher tub onto which a jet of cleaning liquid is sprayed, the predetermined target range for the count value should include some tolerance range which in the example referred to above wherein the spray arm rotates at a speed of 38 rpm may be selected as ±6 peak counts when measuring for a time period of one minute. Given the fact that in situations in which the rotation of the spray arm is blocked either a much higher peak count is achieved, as was explained above by reference to Figs. 5 and 6, or a much lower peak count is determined, as was explained above by reference to Figs. 7 and 8, the rotation of the spray arm can be reliably detected even when selecting a relatively large tolerance range for the peak count. Furthermore, in addition to providing for a target range that is considered to represent a normal rotation of the spray arm, there further can be provided safety ranges at the lower and/or the upper end of the target range, wherein the system is designed to provide for a remeasuring of the spray arm rotation in case that the peak count falls within any of the safety ranges. Thus, the target range for the count value could be selected for example as the standard rotational speed ±2 rpm, wherein it is determined that the spray arm correctly rotates if the count value falls within such target range. On the other hand, should the count value fall within a range of for example 3 to 5 rotations in excess of the design speed in rpm, the measuring cycle is repeated or a further more detailed evaluation routine is conducted. While a similar safety range could be provided at the lower end of the target range it of course is also possible to provide such a safety range in which the evaluation is repeated or altered only at one end of the target range.

[0038] A particularly preferred embodiment of providing for a more sophisticated evaluation of the peak count is by employing a root mean square (RMS) routine in which sample values are obtained over a certain period of time and an average of the individual values is formed which average then is used as basis for a comparison with a predetermined target range.

[0039] In general terms, the RMS value of a discrete signal P of M samples can be written as

$$RMS = \sqrt{\frac{1}{M}\sum_{i=0}^{M-1}(P_i)^2}$$

[0040] Thus, for the n-th measurement the root mean square value RMS_n would be

$$RMS_n = \sqrt{\frac{1}{M}\sum_{i=n\cdot M}^{(n+1)\cdot M-1}(P_i)^2}$$

[0041] In a preferred embodiment instead of calculating the above RMS value the average also could be calculated as

$$Av = \frac{1}{M}\sum_{i=0}^{M-1}|P_i|$$

wherein for the n-th measurement the average Av_n could be calculated as

$$Av_n = \frac{1}{M}\sum_{i=n\cdot M}^{(n+1)\cdot M-1}|P_i|$$

[0042] Taking into account that the output signal of the vibration sensor during normal operation, as it is shown in FIG. 3, is a substantially regular signal comprising a plurality of subsequent adjacent maxima and minima, in a further more sophisticated evaluation method the average of the detected maxima is determined for a certain period of time, the average of the minima detected over such period of time is determined and further the average of all the detected maxima and minima is determined, wherein in order to further rule out data errors each of the detected maxima and minima is compared with the preceding data point.

[0043] In order to make such determination, in a first step the overall mean value of all measured data points, regardless if they are either minima or maxima, can be calculated as

$$Av_{mean} = \frac{1}{N}\sum_{i=0}^{N-1}Av_i$$

[0044] Considering individual data points, in order to make sure that the calculated Av values are real maxima and minima, the measurement values only are considered if the following conditions are fulfilled:

(i) a maximum has to be bigger than the mean value Av_{mean};
(ii) a minimum has to be smaller than the mean value Av_{mean}; and
(iii) a maximum has to be followed by a minimum and vice versa.

[0045] If any of the above rules is not fulfilled, the calculated *Av* value will not be taken into consideration and thus will be discharged.

[0046] Assuming a considered time period in which there are determined a number of *h* maxima and correspondingly a number of *h* minima, these determinations could be written as:

$$Av_{MAX} = \frac{1}{h}\sum_{i=0}^{h-1}Av_{max_i}$$

$$Av_{MIN} = \frac{1}{h}\sum_{i=0}^{h-1} Av_{min_i}$$

$$Av_{MEAN} = \frac{1}{2 \cdot h}\sum_{i=0}^{h-1}\left(Av_{max_i} + Av_{min_i}\right)$$

[0047] An example for a determination of the *Av* value for a normally rotating spray arm is shown in FIG. 9. FIG. 10 is a similar illustration which shows an *Av* chart when received when the spray arm is blocked in an orientation wherein the jet ejected from the driving nozzle impinges onto the wall of the tub remote from the vibration sensor. FIG. 11 shows an example of an *Av* chart obtained in a situation where the spray arm is blocked in an orientation wherein the jet from the driving nozzle hits the wall of the tub close to the sensor.

[0048] From a comparison of the charts illustrated in Figs. 9 to 11 it can be seen that when the spray arm rotates one obtains a low mean value Av_{mean}, but the individual maxima and minima all are relatively far from the mean value Av_{mean} (i.e. high variance).

[0049] In case that the spray arm is blocked far from the sensor, one obtains a low mean value Av_{mean} and the maxima and minima all are close to the mean value Av_{mean} (i.e. low variance). Finally, when the spray arm is blocked in rotation close to the sensor, one obtains a high mean value Av_{mean} but again the individual maxima and minima are close to the mean value (i.e. again low variance).

[0050] Thus, by on the one hand determining the level of the mean value and on the other hand by determining the distance of the individual maxima and minima from such mean value, i.e. by comparing the parameters Av_{mean}, Av_{min} and Av_{max} with predetermined thresholds, it can be reliably determined whether the spray arm is rotating or whether it is blocked, wherein it further can be reliably determined whether such blocking is in an orientation of the spray arm where the jet from the driving nozzle hits the wall of the tub far or remote from the sensor.

[0051] Hence, while in order for the user of the dishwasher to check on a blocked spray arm, the washing cycle carried out in the dishwasher anyway should be interrupted, the differentiation between a blockage of the rotation of the spray arm near or far from the sensor can be used to evaluate whether upon interruption of a washing cycle a delay should be triggered before releasing the lock of the dishwasher door so as to avoid that water is spilled to the exterior of the dishwasher when opening the dishwasher door in a situation where the spray arm is blocked in an orientation where the jet from the driving nozzle is directed towards the door of the dishwasher.

Claims

1. A method for detecting rotation of a dishwasher spray arm, the method comprising:

(a) detecting vibrations generated during operation of the dishwasher;
(b) comparing the level of the detected vibrations with a predetermined threshold, and increasing a count value in dependency of whether the level of the detected vibrations exceeds the predetermined threshold;
(c) comparing the count value that is obtained for a predetermined period of time with a predetermined target range; and
(d) determining that there is a disturbance in the rotation of the spray arm, when the count value is outside the predetermined target range.

2. The method of claim 1, wherein in step (b) the count value is increased only if the level of the detected vibrations exceeds the predetermined threshold for a predetermined duration of time.

3. The method of claim 1 or 2, wherein step (b) further comprises, upon increasing the count value, waiting for a predetermined sampling period and then further increasing the count value if the level of the detected vibrations exceeds the predetermined threshold.

4. The method of claim 3, wherein the sampling period is determined based on a target frequency of rotation of the spray arm.

5. The method of any one of the preceding claims, wherein in step (d) it is determined that the spray arm rotates at a speed that is different from the design speed, when the count value is within a predetermined range that is higher or lower than the predetermined target range.

6. The method of any one of the preceding claims, wherein in step (a) a voltage signal provided by a vibration sensor is converted into a logic signal.

7. The method of claim 6, wherein in step (a) the voltage signal is converted into a transistor-transistor logic (TTL) signal.

8. The method of any one of the preceding claims, further comprising determining a root mean square (RMS) value from a plurality of measurements performed in step (a) and using the thus obtained root mean square (RMS) value in step (b) as level of the detected vibrations.

9. A dishwasher (10) comprising a washing tub (12) for accommodating articles to be cleaned, at least one spray arm (16) arranged within the washing tub for directing a cleaning fluid to the articles to be cleaned, and a vibration sensor (24) for detecting vibrations generated during operation of the dishwasher, **characterized in that** the dishwasher (10) further comprises means for detecting rotation of the spray arm (16) which means is adapted to carry out the process of any one of the preceding claims.

10. The dishwasher of claim 9, wherein the vibration sensor (24) comprises a piezoelectric shock sensor.

11. The dishwasher of claim 9 or 10, wherein the vibration sensor (24) is adapted to produce a voltage output signal that is substantially proportional to the acceleration of the sensor caused by a mechanical vibration of the sensor.

12. The dishwasher of any of claims 9 to 11, wherein the vibration sensor (24) is attached to the exterior side of the tub (12).

13. The dishwasher of claim 12, wherein the vibration sensor (24) is attached to a side wall (26) of the tub (12).

14. The dishwasher of claim 13, wherein the spray arm (16) comprises at least one driving nozzle (20) for emitting a water jet at an angle to the axis (22) of rotation of the spray arm, and wherein the vibration sensor (24) is attached to a side wall (26) of the tub (10) at about the level where the water jet emitted from the driving nozzle hits the side wall of the tub.

15. The dishwasher of any of claims 12 to 14, wherein the vibration sensor (24) is attached to the exterior side of the tub (12) by a substantially rigid connection.

16. The dishwasher of any of claim 15, wherein the vibration sensor (24) is glued directly to the exterior side of the tub (12).

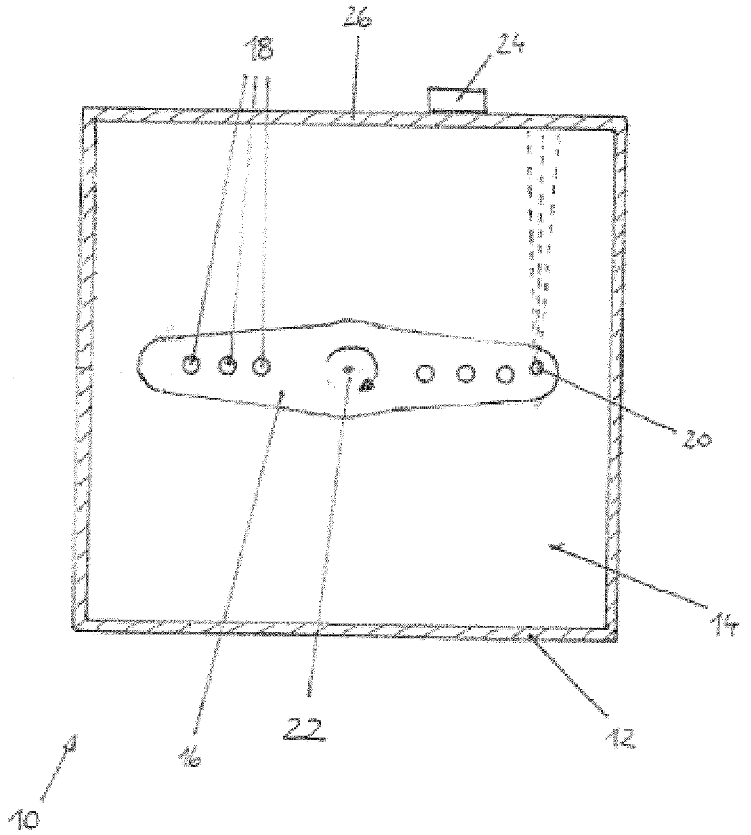
26
24
18
20
14
12
22
16
10

FIG. 1

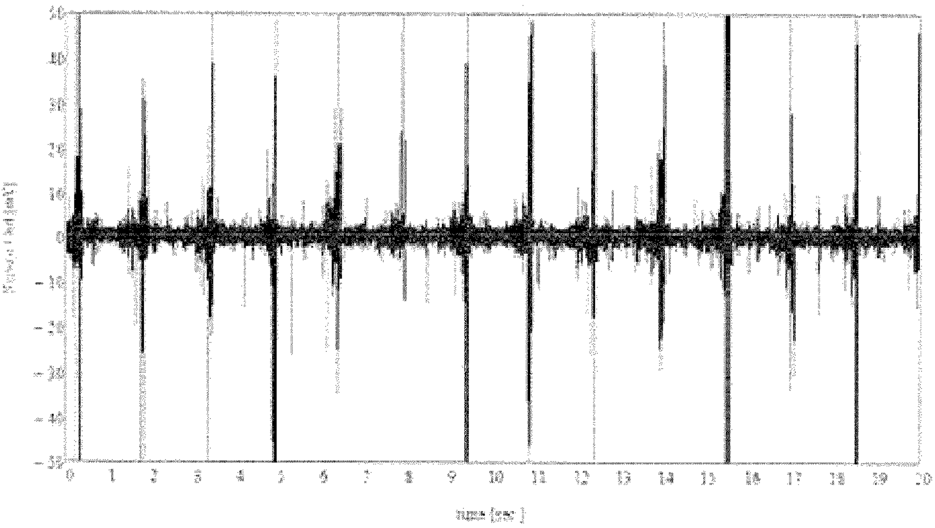
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

FIG. 2

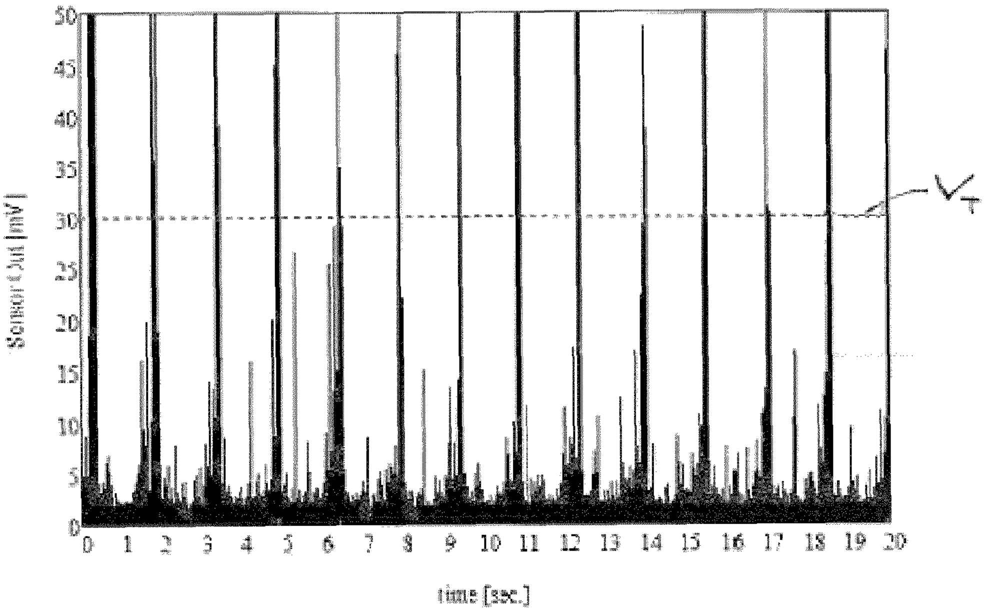

FIG. 3

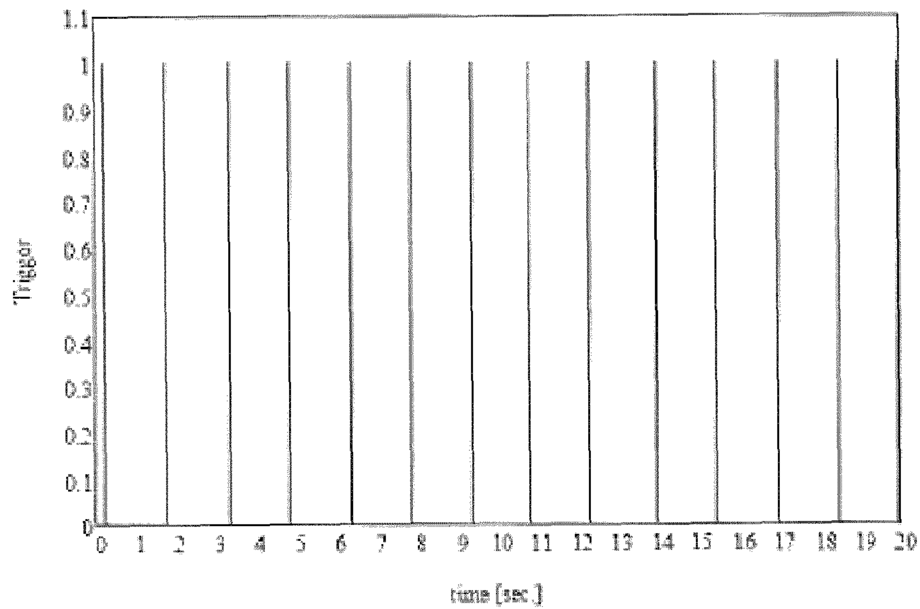

FIG. 4

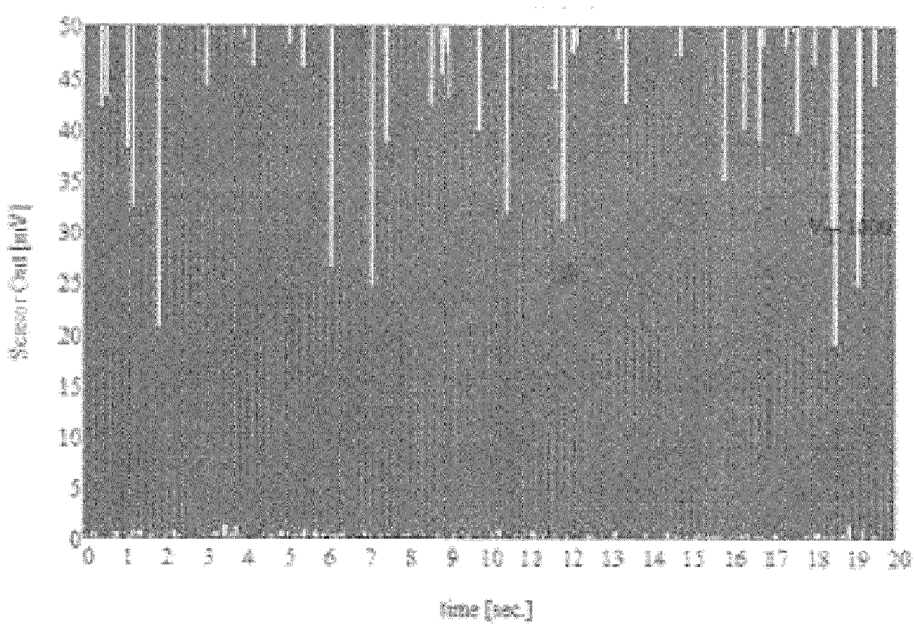

FIG. 5

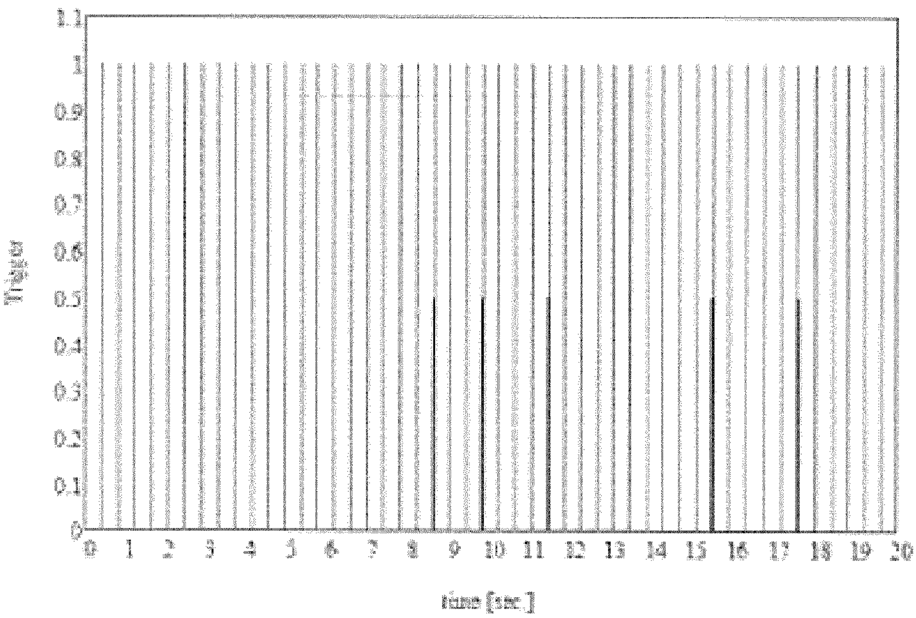

FIG. 6

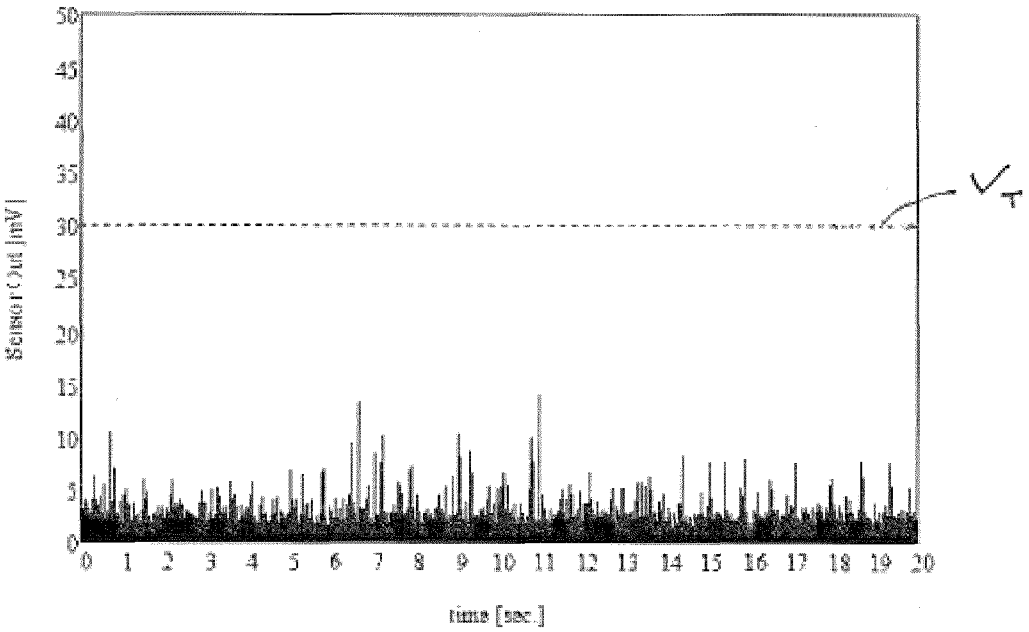
Sensor Out [mV]
50
45
40
35
30
25
20
15
10
5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
time [sec.]

FIG. 7

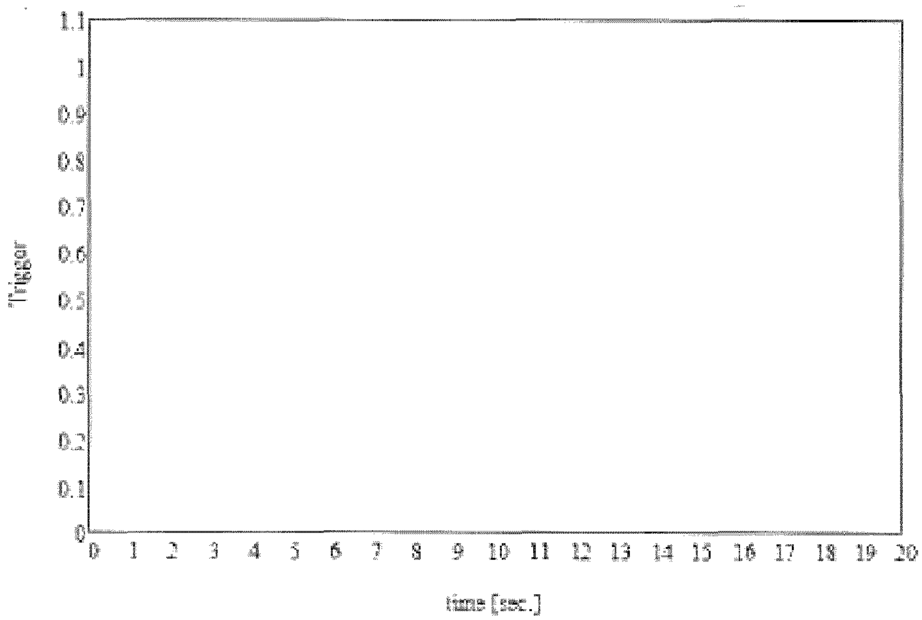
Trigger
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
time [sec.]

FIG. 8

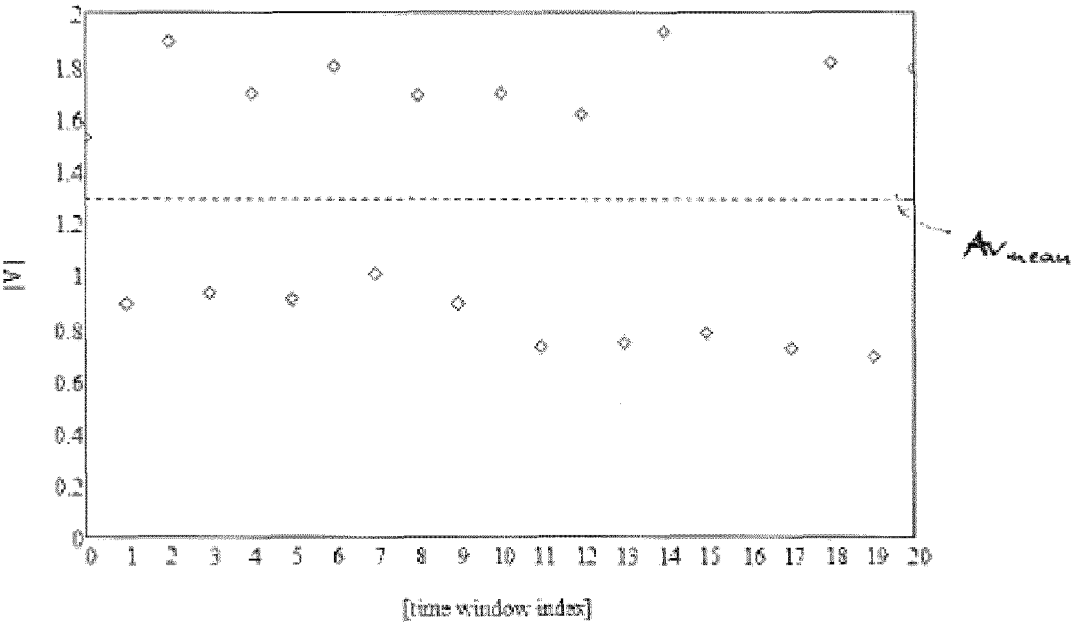
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
|V|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
[time window index]
AVmean

FIG. 9

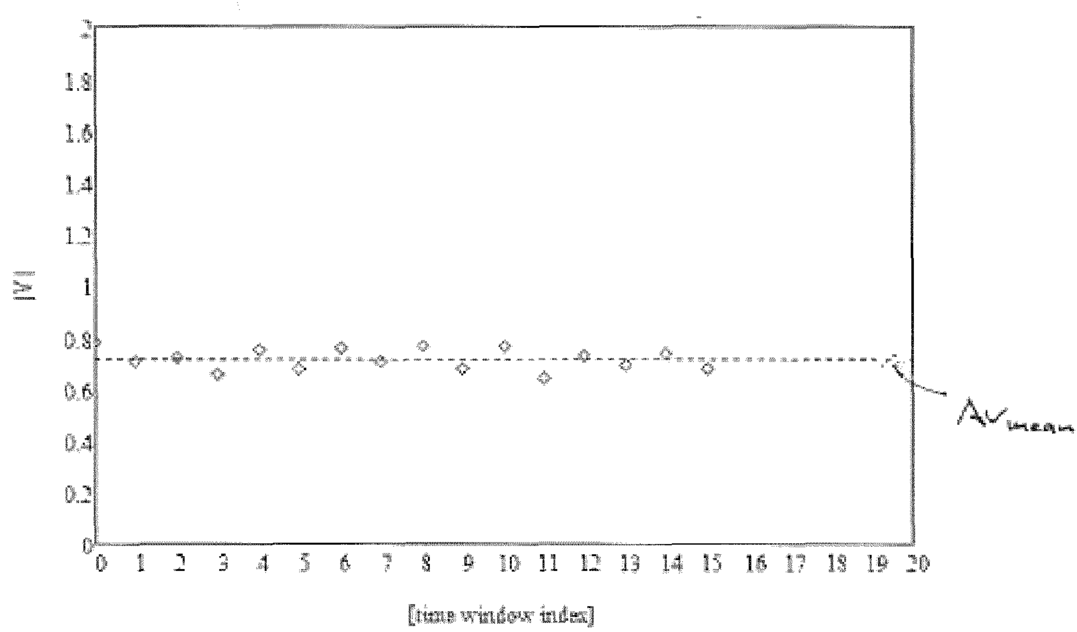
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
|V|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
[time window index]
AVmean

FIG. 10

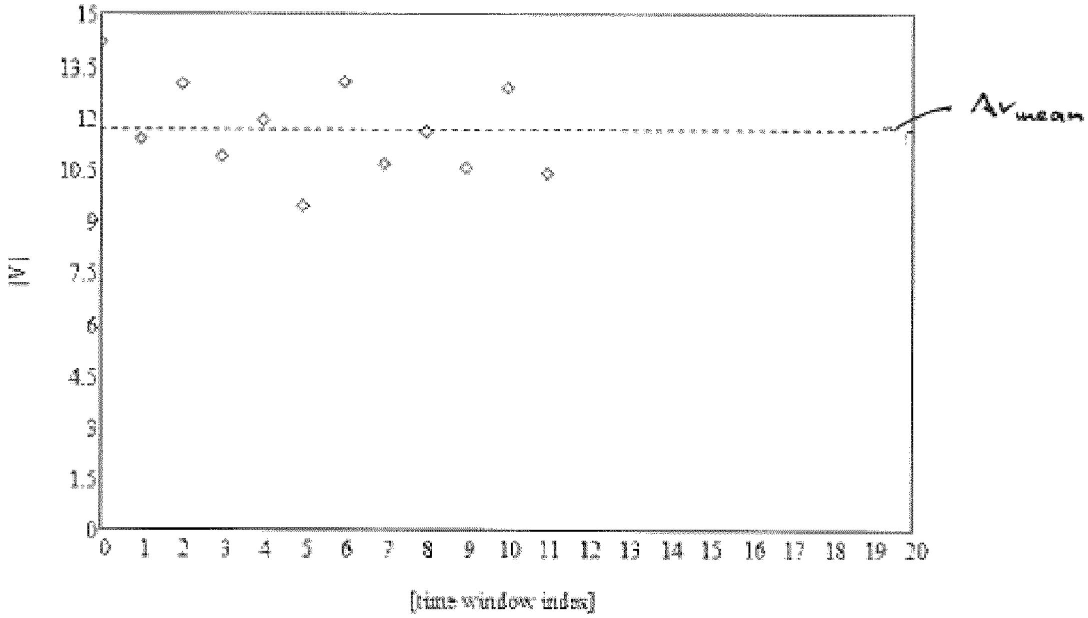
15
13.5
12
10.5
9
7.5
6
4.5
3
1.5
0
|V|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
[time window index]
Av_{mean}

FIG. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 12 15 0555

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	US 2010/170541 A1 (POYNER DENNIS A [US] ET AL) 8 July 2010 (2010-07-08) * claim 8 *	1-16	
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	9 July 2012	Lodato, Alessandra

CATEGORY OF CITED DOCUMENTS

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