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(54) Control system for a range hood having an automatic fume detection device and control method

(57) A control system for a range hood (1) having an automatic fume detection device is provided, wherein the system includes a main control module (2) for controlling operation of the range hood (1), a key display module (4), and an ultrasonic module (3) for controlling the automatic fume detection device. The ultrasonic module (3) is independent of the main control module (2) in structure. The ultrasonic module (3) is connected to the main control module (2) through a power line and a data line. The ultrasonic module (3) is independent of the key display module (4) in structure. The ultrasonic module (3) is connected to the key display module (4) through a data line.

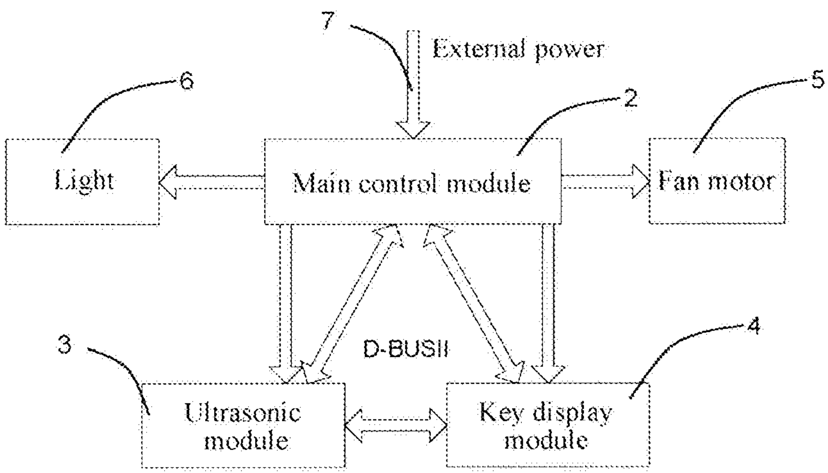

FIG. 2

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a range hood, and more particularly to a control system for a range hood implementing an automatic fume detection through an ultrasonic technology, and a control method for the range hood.

Related Art

[0002] A range hood is a widely used every-day household kitchen appliance. Through the development of science and technology, intelligent devices have become an inevitable development trend in the field of household appliances. Conventionally, when a range hood is operated, a user selects a corresponding operational state according to a using habit, for example, he selects a tap configuration or a position of a control element for a fan speed such as 1, 2 or 3. For such a range hood, the user needs to manually operate the range hood according to a fume state. Another disadvantage of such a range hood is that the fan is often in a state corresponding to a fixed pre-set tap position, and the tap position may be either too low for realizing a good fume extraction effect, or too high such that energy may be wasted. Therefore, it is desirable to design a range hood capable of intelligently changing a tap position of the range hood according to a fume situation.

[0003] Chinese Utility Model Patent Application 200920000606.X discloses a range hood that automatically regulates a ventilation speed according to a fume density. A device for detecting the fume density is a photoelectric detection unit installed at the range hood. The photoelectric detection unit includes a light emitter and a photoelectric detector, and a space exists between the light emitter and the photoelectric detector. The fume from the surrounding environment may enter the space and can be detected by the photoelectric detection unit. A disadvantage of such a design is that an emission source of the light emitter and a receiving source of the photoelectric detector must be kept clean enough; otherwise, the sensitivity and feedback accuracy of the detection may be severely affected. It is inevitable that a large amount of fume is generated in an environment where the range hood is used. After long periods of use, it is hard to keep the range hood sufficiently clean.

[0004] Another technology used for detecting a fume density employs ultrasonic waves. Ultrasonic technology has advanced rapidly in recent years. An acoustic signal of the ultrasonic wave responds well to fume. Therefore, the application of ultrasonic technology to fume detection may improve the efficiency of range hoods and improve the user friendliness substantially. In U.S. Patent Applications US 5,074,281 and US 6,324,889 B 1 technical solutions for detecting a fume density by using ultrasonic waves are disclosed. However, during operation of the range hood, due to influences of a variety of factors such as environmental temperature and environmental humidity at a circuit board, an ultrasonic sensor and an ultrasonic signal, a signal received by the ultrasonic sensor may become too great or too small. It is then hard to determine an influence of the fume on the ultrasonic signal, which can affect the accuracy of the ultrasonic fume detection.

SUMMARY OF THE INVENTION

[0005] The present invention is directed to a control system for a range hood, in particular for an automatic fume detection device of a range hood, which is easy to install.

[0006] The present invention is further directed to a control method for a range hood having an automatic fume detection device, so as to improve an accuracy of a fume detection.

[0007] Accordingly, a control system for a range hood having an automatic fume detection device according to an embodiment of the present invention includes a main control module for controlling an operation of the range hood, a key display module, and an ultrasonic module for controlling the automatic fume detection device. The ultrasonic module is structurally independent or independent in structure from the main control module. The ultrasonic module is connected to the main control module through a power line and a data line. The ultrasonic module is structurally independent or independent in structure from the key display module. The ultrasonic module is connected to the key display module through a data line.

[0008] As a further improvement of the present invention, the key display module is structurally independent or independent in structure from the main control module, and the key display module is connected to the main control module through a power line and a data line.

[0009] As a further improvement of the present invention, the main control module, the ultrasonic module, and the key display module are connected through the data lines and exchange information through a D-BUS II communication protocol.

[0010] As a further improvement of the present invention, the ultrasonic module includes a Micro Control Unit (MCU), an oscillator, a first amplifier, a shaping circuit, an ultrasonic sensor, a first switch, a second amplifier, a band-pass filter, a peak detection circuit, and a second switch connected in sequence.

[0011] As a further improvement of the present invention, the second amplifier is an amplifier having an adjustable amplification factor.

[0012] As a further improvement of the present invention, the MCU is capable or adapted to send or transmit an Enable instruction to the oscillator, an ON/OFF instruction to the first switch and/or the second switch, and to send an amplification factor adjustment instruction to the second amplifier.

[0013] Accordingly, in a control method for operating a control system of a range hood having an automatic fume detection device according to an embodiment of the present invention, a control process of the ultrasonic module includes the following steps:

a) Enabling the oscillator, and maintaining both the first switch and the second switch in an OFF state.

b) The oscillator sends an excitation signal; the first amplifier amplifies and generates an excitation signal. Both the first switch and the second switch are maintained in the OFF state.

c) Waiting for an ultrasonic feedback signal, and maintaining both the first switch and the second switch in the OFF state.

d) Turning on the first switch, and receiving a feedback signal. The second amplifier amplifies the feedback signal. The second switch is maintained in the OFF state.

e) Turning on the second switch to start analog-to-digital (AD) sampling, and maintaining the first switch and the second switch in an ON state.

[0014] The control method for the control system of the range hood having the automatic fume detection device may further include the following step: calculating a fan speed according to AD sampling data, and maintaining both the first switch and the second switch in the OFF state.

[0015] Accordingly, in a control method for a control system of a range hood having an automatic fume detection device according to an embodiment of the present invention, a control process of the ultrasonic module includes the following steps:

a) Presetting ultrasonic signal threshold values V_{MAX} and V_{MIN} in the MCU.

b) Performing signal sampling and obtaining a mean sampled value $V_{MeanValue}$.

c) Comparing the mean sampled value $V_{MeanValue}$ with the ultrasonic signal threshold values V_{MAX} and V_{MIN}, and adjusting the amplification factor of the second amplifier according to a comparison result.

[0016] As a further improvement of the present invention, the step of adjusting the amplification factor of the second amplifier includes the following steps:

c1) If the mean sampled value $V_{MeanValue} > V_{MAX}$, decreasing the amplification factor of the second amplifier until $V_{MeanValue} < V_{MAX}$.

c2) If the mean sampled value $V_{MeanValue} < V_{MIN}$, increasing the amplification factor of the second amplifier until $V_{MeanValue} > V_{MIN}$.

[0017] The ultrasonic module is, for example, implemented to execute a control method described above.

[0018] Beneficial effects of embodiments of the present invention are as follows. First, the ultrasonic module is independent of the main control module, so that the ultrasonic module may be freely installed on any proper position at or on the range hood, which not only makes full use of space but also makes it convenient for the design of the entire system. Second, by turning ON/OFF the two switches of the ultrasonic module in sequence, an OFF noise input of the switches during amplification of a small signal is effectively prevented. Third, by adjusting the amplification factor of the second amplifier, the mean sampled value $V_{MeanValue}$ falls in a reasonable interval, thereby ensuring that the ultrasonic signal is capable of accurately reflecting influences of the fume.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

FIG. 1 is a schematic structural view of an embodiment of a range hood;

FIG. 2 is a schematic view of an embodiment of a control system for a range hood;

FIG. 3 is a detailed schematic structural view of an ultrasonic module shown in FIG. 2;

FIG. 4 is a schematic view of a flow chart for a process in a control system for a range hood;

FIG. 5 is a schematic view of a flow chart for a control process for an ultrasonic module shown in FIG. 2;

FIG. 6a is a schematic view of a distribution of sample values of an ultrasonic signal when a range hood is started and no fume exists;

FIG. 6b is a schematic view of a distribution of sample values of an ultrasonic signal when a range hood is started and fume exists;

FIG. 7a is a schematic view of a distribution of mean values of sampled signals corresponding to FIG. 6a; and

FIG. 7b is a schematic view of a distribution of mean values of sampled signals corresponding to FIG. 6b.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0020] Referring to FIG. 1, a range hood 1 according to an embodiment of the present invention includes a hood body 10 and a volute 11 installed in the hood body 10. A fan driven by an electric motor is installed in the volute 11. When the fan rotates, the fan carries the fume away. The structure and working principle of the range hood 1 are the same as range hoods commonly used in the market, the detailed description of which is omitted here. A first filter device 12 is disposed at an opening of the hood body 10 towards a fume source. In this embodiment, the first filter device 12 is a grid-shaped metal filter mesh. Through a gap arrangement of the metal filter mesh, a part of the grease in the outside fume is filtered when the fume passes through the filter mesh. However, the metal filter mesh is incapable of completely filtering all the grease and other odorous impurities in the fume. An ultrasonic sensor arrangement is installed in an internal space of the hood body 10, and is located behind the first filter device 12. Here, "behind" means that the outside fume has to pass through the first filter device 12 before reaching the ultrasonic sensor. The ultrasonic sensor arrangement includes a signal generator 14 and a signal feedback device 15. In this embodiment, the signal generator 14 and the signal feedback device 15 are installed at two opposite side walls in the inner space of the hood body 10. In this manner, a space passage for the fume is formed for passing between the signal generator 14 and the signal feedback device 15. An ultrasonic signal is emitted by the signal generator 14 and fed back by the signal feedback device 15 through the space passage, thereby one obtains an interference state of the ultrasonic signal passing through the space passage, and one may determine the density of the fume passing through the space passage. An embodiment of a method for determining the fume density is described in detail in the following. A second filter device 13 is disposed between the volute 11 and the ultrasonic sensor arrangement. In this embodiment, the second filter device 13 is a fine filter mesh comprising a carbon (such as active carbon) material. Since the grid-shaped gap of the first filter device 12 is larger and does not completely filter the impurities in the fume, the arrangement of the second filter device 13 may further filter the fume to make the fume sufficiently clean to be discharged to an external environment. It should be noted that, in other embodiments of the present invention, the second filter device 13 can be mandatory. Preferably, the ultrasonic sensor arrangement of the present embodiment should not be installed behind the second filter device 13, so as to avoid that the density of the fume passing through the ultrasonic sensor arrangement is too low to be detected.

[0021] Referring to FIG. 2, a control system for a range hood according to an embodiment of the present invention includes a main control module 2, an ultrasonic module 3, a key display module 4, a fan motor 5, a light 6, and an external power line 7. The main control module 2 acts as a control center of the range hood, and includes a circuit board having a control chip. An installation position of the main control module 2 may be any proper position in or at the hood body 10 such as the position behind the key display module 4. Driven by the external power 7, the main control module 2 receives instruction signals from the ultrasonic module 3 and the key display module 4, and correspondingly sends instruction signals to the ultrasonic module 3, the key display module 4, the fan motor 5 and the light 6. The ultrasonic module 3 is an independent module, and a specific architecture thereof is shown in FIG. 3, which will be described in detail in the following. The ultrasonic module 3 and the main control module 2 may be connected through a power line and a data line, and exchange information through a D-BUS II communication protocol. Such a design enables the ultrasonic module 3 to be independent of the main control module 2 and capable of being freely installed at any proper position of the range hood. For example, the ultrasonic module 3 may be installed close to the ultrasonic sensor arrangement, which allows for an efficient use of the space, and also facilitates the design of the entire system (if the ultrasonic module 3 is integrated in the main control module 2, the size of an entire control unit may be too large to be placed at a proper position for installation). The key display module 4 may be connected to the main control module 2 through a power line and a data line, and can be connected to the ultrasonic module 3 through a data line, and exchange information through the D-BUS II communication protocol. The key display module 4 receives a key instruction input from an operator and sends information to the main control module 2 according to the key instruction, so as to control the operation of the range hood. The key display module 4 may also send information to the ultrasonic module 3 to control the operation of the ultrasonic module. Similarly, the key display module 4 may also display control instructions sent by the main control module 2 and the ultrasonic module 3 or display working state information of the range hood, so that the operator obtains information on a working state of the range hood. The fan motor 5 and the light 6, respectively, receive the instructions from the main control module 2 in a unidirectional fashion for implementing a start/stop/speed-shift of the motor 5, or on/off of the light 6.

[0022] Referring to FIG 2, the control system for or the method for controlling the range hood of the present invention may include seven steps comprising Step S 1 to Step S7 in total. After the seven steps, the ultrasonic module of the range hood stays in a normal working state.

[0023] Referring to FIG 3, the ultrasonic module 3 includes an MCU 30, an oscillator 31, a first amplifier 32, a shaping circuit 33, an ultrasonic sensor arrangement 34, a first switch 35, a second amplifier 36, a band-pass filter 37, a peak detection circuit 38, and a second switch 39. A working principle of the ultrasonic module 3 is that the MCU 30 controls and enables an oscillation frequency of the oscillator 31, a state of the first switch 35 and the second switch 39, and an amplification factor of the second amplifier 36. The oscillator 31 is capable of generating a signal of a certain frequency. The first amplifier 32 amplifies an output signal of the oscillator 31 to a certain amplitude. The shaping circuit 33 shapes the output signal of the first amplifier 32 and outputs the shaped signal to the ultrasonic sensor arrangement 34. The ultrasonic sensor arrangement 34 receives an excitation signal output by the shaping circuit 33, sends an acoustic signal and receives a feedback signal. The second amplifier 39 amplifies the feedback signal. The band-pass filter 37 filters the amplified feedback signal. The peak detection circuit 38 extracts a peak voltage from an alternating current (AC) feedback signal and outputs the voltage peak to the MCU 30 for AD sampling.

[0024] A device implementing and/or a method for operating the ultrasonic module 3 of the present invention may have the following features. In structure, two switches are disposed, namely the first switch 35 and the second switch 39. In the respective process or method, referring to FIG 5, the two switches are turned ON/OFF in sequence, therefore effectively reducing an OFF noise input during an amplification process of a small signal. The detailed operation is described as follows.

[0025] In Step S30, the oscillator 31 is enabled; the first switch 35 and the second switch 39 are both maintained in an OFF state.

[0026] In Step S31, an excitation signal is sent by the oscillator 31; the first amplifier 32 amplifies and sends the excitation signal; and the first switch 35; and the second switch 39 are both maintained in their OFF state.

[0027] In Step S32, it is waited for an ultrasonic feedback signal, and the first switch 35 and the second switch 39 are both maintained in the OFF state.

[0028] In Step S33, the first switch 35 is turned on; a feedback signal is received; the second amplifier 36 amplifies the feedback signal; and the second switch 39 is maintained in the OFF state.

[0029] In Step S34, the second switch 39 is turned on to start AD sampling, and the first switch 35 and the second switch 39 are both maintained in an ON state.

[0030] In Step S35, during an idle time, a fan speed is calculated as a function of the sampled data, and the first switch 35 and the second switch 39 are both maintained in the OFF state.

[0031] An ultrasonic system is affected by many factors such as environmental temperature, environmental humidity and fume. These factors may affect the circuit board, the ultrasonic sensors and the ultrasonic signal, so that the received ultrasonic feedback signal changes. For example, when the environmental temperature and the environmental humidity change rapidly, the ultrasonic signal may become too great or too small. As an example, rapid changes of the environmental temperature and the environmental humidity can result in a great value of the ultrasonic signal in a fumeless situation, which may cause a problem, i.e. the amplitude of the ultrasonic signal is too great, and when the fume exists, many sampled ultrasonic signals are saturation values. A mean value of the ultrasonic signals is great and a fluctuation interval of the mean value is small, and therefore, it is difficult for the system to determine whether fume exists. In another example, the rapid changes of the environmental temperature and the environmental humidity can result in a small value of the ultrasonic signal in a fumeless situation, which may cause another problem, i.e. the amplitude of the ultrasonic signal is too small, and the ultrasonic signal fluctuates in a small range no matter fume exists or not. Therefore, it is also difficult for the system to determine whether fume exists.

[0032] In view of the above problems, according to another feature of the ultrasonic module 3, the second amplifier 36 is an amplifier having an adjustable amplification factor. The amplification factor can be controlled through the MCU 30. Such structure in combination with an appropriate system software is capable of solving the problem that the rapid or violent changes of the environmental temperature and the environmental humidity affect the ultrasonic signal. Ultrasonic signal threshold values V_{MAX} and V_{MIN} are preset in the MCU 30, and the amplification factor of the second amplifier 36 is adjusted as a function of the sampled actual ultrasonic signals.

[0033] When the mean sampled value $V_{MeanValue} > V_{MAX}$, the amplification factor of the second amplifier 36 is decreased until $V_{MeanValue} < V_{MAX}$.

[0034] When the mean sampled value $V_{MeanValue} < V_{MIN}$, the amplification factor of the second amplifier 36 is increased until $V_{MeanValue} > V_{MIN}$.

[0035] In this manner, the mean sampled value $V_{MeanValue}$ falls in a reasonable interval, thereby ensuring that the ultrasonic signal is capable of accurately reflecting an influence of the fume.

[0036] Referring to FIG. 6a to FIG. 7b, the working principle of embodiments of the range hood having the automatic fume detection device and the control method thereof are described in the following.

[0037] An ultrasonic signal is affected by many factors such as environmental temperature, environmental humidity and fume. However, if the ultrasonic sensor is disposed inside the hood body of the range hood, as shown in FIG. 1, the influence of the factors such as environmental temperature and environmental humidity on the ultrasonic signal is relatively uniform. FIG. 6a shows a distribution state of sampled values of an ultrasonic signal at a certain fan speed. It can be seen from FIG. 6a that the distribution of the sampled values of the ultrasonic signal is relatively uniform. Definitely, the fan speed also influences the sampled values. Generally speaking, the greater the fan speed is, the greater is the discreteness of the sampled values.

[0038] FIG. 6b shows the influence of the fume on the sampled signals at the same fan speed. Before the fume appears, the sampled values of the ultrasonic signal are relatively concentrated, and the values are relatively great. After the fume appears, the sampled values of the ultrasonic signal fluctuate in a relatively great range, and the sampled values tend to be low. After the fume disappears, the sampled values of the ultrasonic signal return to the relatively great values and fluctuate in a small range.

[0039] Mean values of the sampled signals are calculated in a certain period, and graphs of the mean values shown in FIG. 7a and FIG. 7b are obtained according to the signals of FIG. 6a and FIG. 6b respectively. Comparing FIG. 7a and FIG. 7b, it can be seen that the influence of the fume on the mean values of the sampled ultrasonic signal leads to a change in the distribution, that is, when no fume exists, the signal curve is relatively smooth and stable; after the fume is generated, since the fume weakens the ultrasonic signal, the amplitude of the curve decreases. Moreover, due to an inhomogeneity of the fume, the signal jumps rapidly, which is reflected by an up-and-down oscillation in the signal curve. Therefore, embodiments of the present invention comprise two approaches for determining the density of the fume as a function of a change of amplitude of the mean value.

[0040] According to a first aspect, different threshold mean values are set for different fan speeds. When the mean value of the sampled ultrasonic signal is lower than a pre-set threshold value, it is determined that the fan speed needs to be increased. When the mean value of the sampled ultrasonic signal is higher than a pre-set threshold value, it is determined that the fan speed needs to be decreased. For example, threshold values Vspeed1 and Vspeed2 are respectively set for fan speeds Speed1 and Speed2. $V_{MeanValue}$ is a mean value of sampled signals in a period between T1 and T2. When the sampled value $V_{MeanValue}$ < Vspeed1, the fan speed is increased from tap position 1 to tap position 2. When the sampled value $V_{MeanValue}$ > Vspeed2, the fan speed is decreased from tap position 2 to tap position 1.

[0041] According to a second aspect, different mean value fluctuation ranges are pre-set for different fan speeds, and the mean values that exceed the pre-set range are counted over a certain period. A pre-set count threshold value is changed for different fan speeds, so as to determine a change of the fan speed. For example, different fluctuation range criteria are set for different fan speeds: Speed1 corresponds to an interval ($V_{speed1min}$, $V_{speed1max}$), and Speed2 corresponds to an interval ($V_{speed2min}$, $V_{speed2max}$). $V_{MeanValue}$ is a mean value of the sampled signals in a period between T1 and T2. At Speed1, if $V_{MeanValue}$ of the sampled ultrasonic signals in the period between T1 and T2 exceeds ($V_{speedmin}$, $V_{speedmax}$) by a number of counted values larger than a pre-set criterion C_{max}, it is regarded that the fume is relatively thick, and the fan speed is increased from tap position 1 to tap position 2. At Speed2, if $V_{MeanValue}$ of the sampled ultrasonic signals in the period between T1 and T2 exceeds ($V_{speedmin}$, $V_{speedmax}$) by a number of counted values smaller than a pre-set criterion C_{min}, it is regarded that the fume is relatively thin, and the fan speed is decreased from tap position 2 to tap position 1.

[0042] An advantage of the first aspect and the second aspect is that valid information of the influence of the fume on the ultrasonic signal is fully extracted using a smart algorithm. The two methods may be embodied independently or may be combined according to the specific design of the range hood, thereby allowing an automatic change of the fan speed of the range hood according to the fume state.

[0043] Preferred embodiments of the present invention are described above. It should be noted that, based on the disclosure of the embodiments, adaptive modifications may be made by persons with ordinary skills in the art without any creative work. These reasonable modifications shall fall within the protection scope of the present invention.

Claims

1. A control system for range hood (1) having an automatic fume detection device, the control system comprising:

   a main control module (2) for controlling an operation of the range hood (1),
   a key display module (4), and
   an ultrasonic module (3) for controlling the automatic fume detection device,
   wherein the ultrasonic module (3) is structurally independent from the main control module (2), and the ultrasonic module (3) is connected to the main control module (2) through a power line and a data line; and
   wherein the ultrasonic module (3) is structurally independent from the key display module (4), and the ultrasonic module (3) is connected to the key display module (4) through a data line.

2. The control system according to claim 1, **characterized in that** the key display module (4) is structurally independent from the main control module (2), and the key display module (4) is connected to the main control module (2) through a power line and a data line.

3. The control system according to claim 1 or 2, **characterized in that** the main control module (2), the ultrasonic module (3), and the key display module (4) are connected through the data lines and exchange information through a D-BUS II communication protocol.

4. The control system according to any one of claims 1 - 3, **characterized in that** the ultrasonic module (3) comprises a Micro Control Unit (30), an oscillator (31), a first amplifier (32), a shaping circuit (33), an ultrasonic sensor (34), a first switch (35), a second amplifier (36), a band-pass filter (37), a peak detection circuit (38), and a second switch (39) connected

in sequence.

5. The control system according to claim 4, **characterized in that** the second amplifier (36) is an amplifier having an adjustable amplification factor.

6. The control system according to claim 5 or 6, **characterized in that** the Micro Control Unit (30) is adapted to transmit an Enable instruction to the oscillator (31), an ON/OFF instruction to the first switch (35) and/or the second switch (39), and to send an amplification factor adjustment instruction to the second amplifier (36).

7. A control method for operating the control system according to any one of claims 4 - 6, wherein a control process for the ultrasonic module (3) comprises:

a) enabling the oscillator (31), and maintaining both the first switch (35) and the second switch (39) in an OFF state;
b) generating an excitation signal with the oscillator (31), amplifying the excitation signal by the first amplifier (32), and maintaining both the first switch (35) and the second switch (39) in the OFF state;
c) waiting for an ultrasonic feedback signal, and maintaining both the first switch (35) and the second switch (39) in the OFF state;
d) turning on the first switch (35), receiving a feedback signal, amplifying the feedback signal by the second amplifier (36), and maintaining the second switch (39) in the OFF state; and
e) turning on the second switch (39) to start analog-to-digital sampling for obtaining AD sampling data, and maintaining the first switch (35) and the second switch (39) in an ON state.

8. The control method according to claim 7, further comprising: calculating a fan speed as a function of the AD sampling data, and maintaining the first switch (35) and the second switch (39) in the OFF state.

9. A control method for operating the control system according to claim 5 or 6, wherein a control process of the ultrasonic module (3) comprises:

a) presetting ultrasonic signal threshold values V_{MAX} and V_{MIN} in the Micro Control Unit;
b) performing signal sampling for obtaining a mean sampled value $V_{MeanValue}$; and
c) comparing the mean sampled value $V_{MeanValue}$ with the ultrasonic signal threshold values V_{MAX} and V_{MIN}, and adjusting the amplification factor of the second amplifier (36) according to a comparison result.

10. The control method according to claim 9, **characterized in that** adjusting the amplification factor of the second amplifier comprises:

c1) if the mean sampled value $V_{MeanValue} > V_{MAX}$, decreasing the amplification factor of the second amplifier (36) until $V_{MeanValue} < V_{MAX}$; and
c2) if the mean sampled value $V_{MeanValue} < V_{MIN}$, increasing the amplification factor of the second amplifier (36) until $V_{MeanValue} > V_{MIN}$.

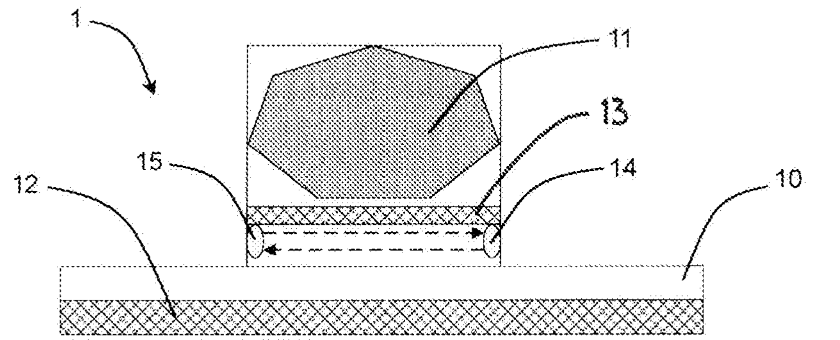

FIG. 1

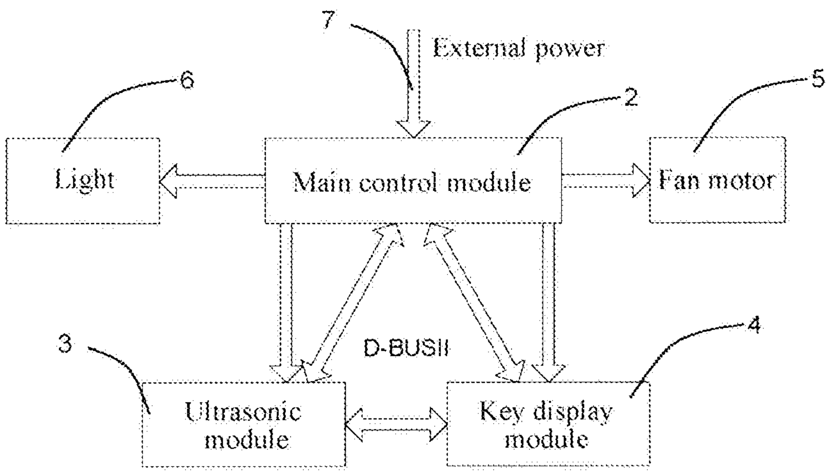

FIG. 2

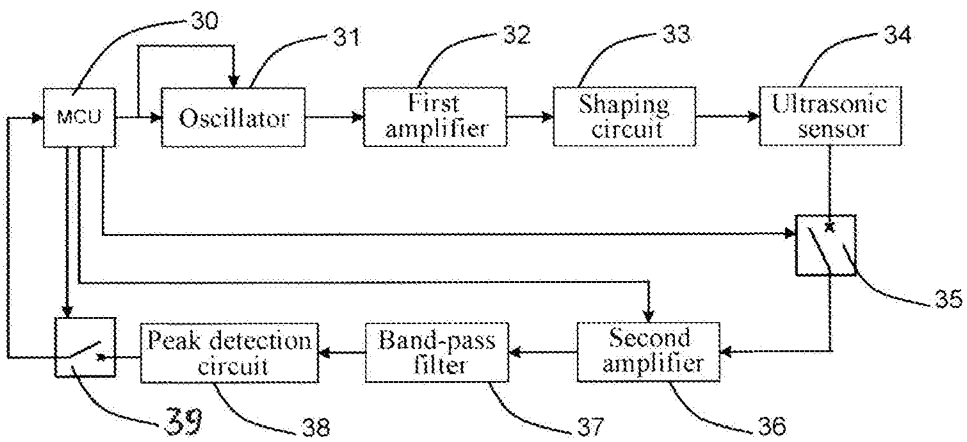

FIG. 3

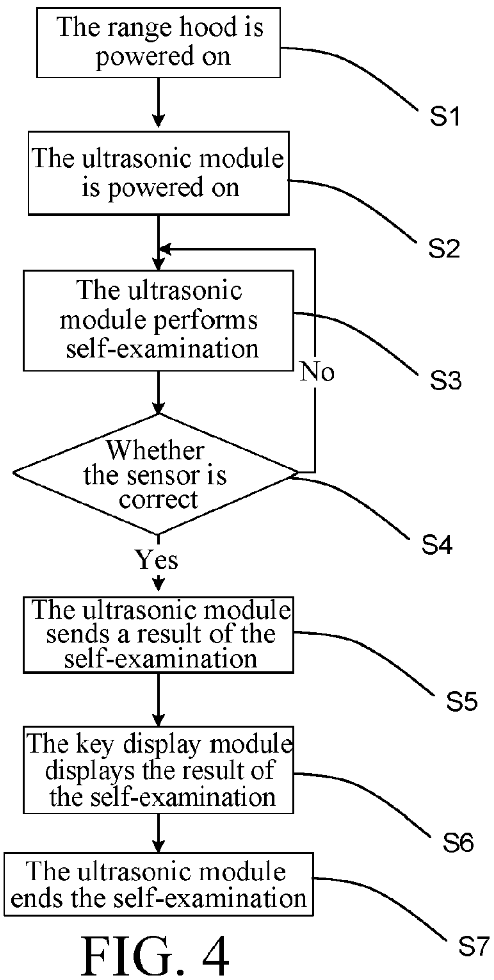
The range hood is powered on
S1
The ultrasonic module is powered on
S2
The ultrasonic module performs self-examination
S3
No
Whether the sensor is correct
S4
Yes
The ultrasonic module sends a result of the self-examination
S5
The key display module displays the result of the self-examination
S6
The ultrasonic module ends the self-examination
S7

FIG. 4

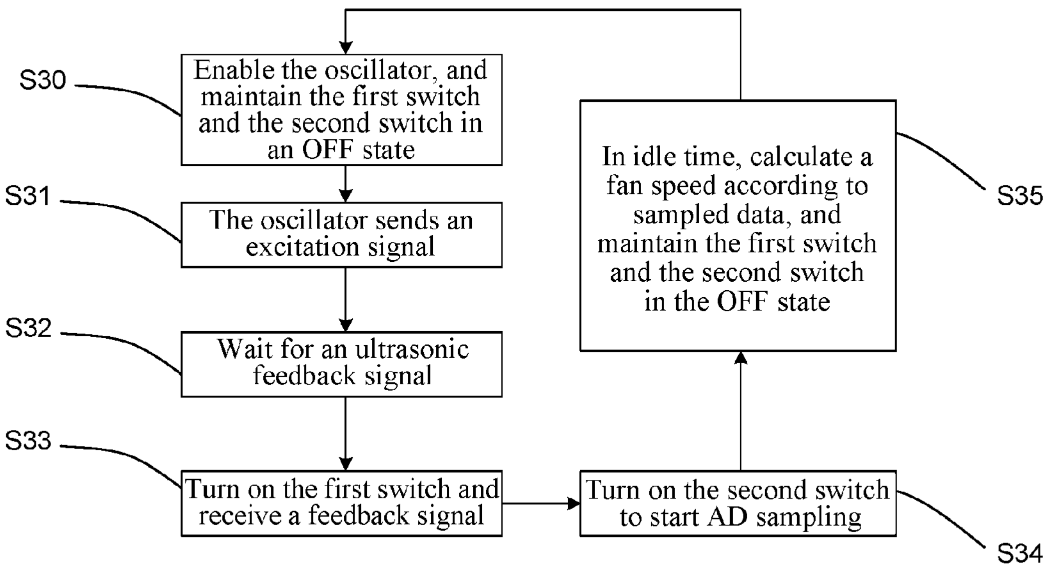
S30
Enable the oscillator, and maintain the first switch and the second switch in an OFF state
S31
The oscillator sends an excitation signal
S32
Wait for an ultrasonic feedback signal
S33
Turn on the first switch and receive a feedback signal
Turn on the second switch to start AD sampling
S34
In idle time, calculate a fan speed according to sampled data, and maintain the first switch and the second switch in the OFF state
S35

FIG. 5

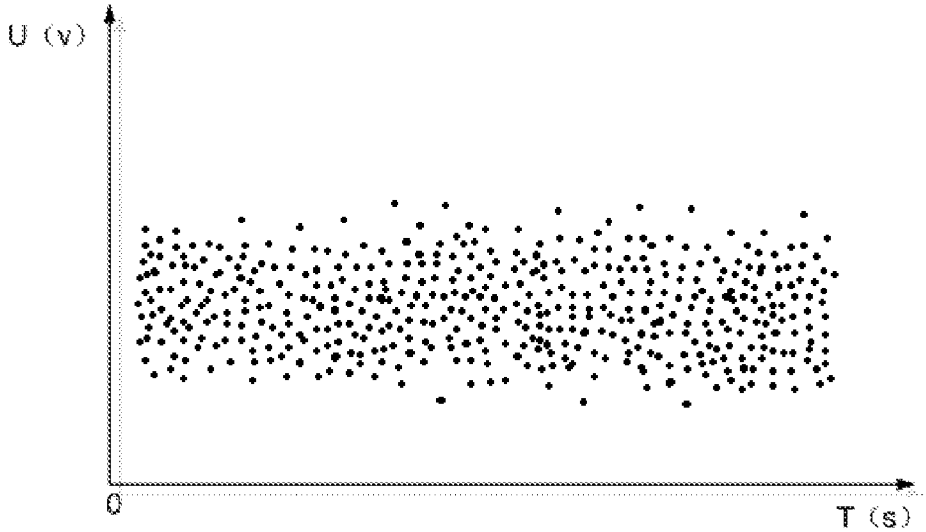

FIG. 6a

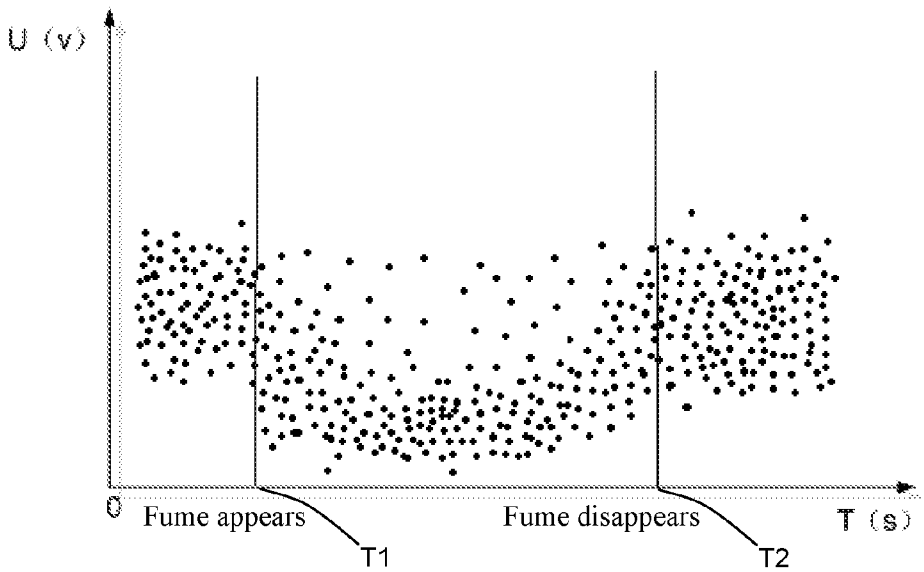

FIG. 6b

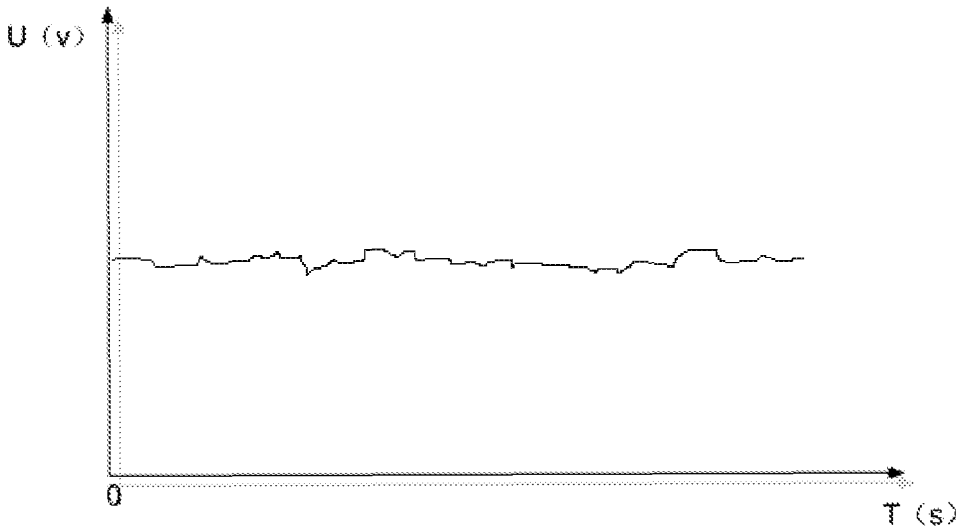

FIG. 7a

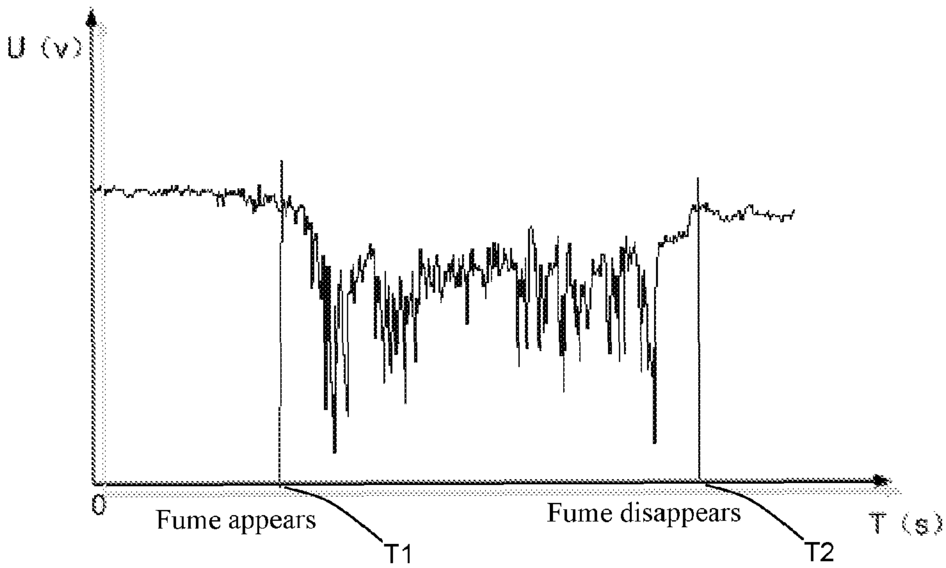

FIG. 7b

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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