According to one embodiment, an electronic device includes a fan, a temperature sensor and a controller. The temperature sensor is configured to output a value indicative of a detected temperature. The controller is configured to control a rotational speed of the fan. The controller is configured to keep the rotational speed of the fan constant when the value is within a first temperature zone or to change the rotational speed of the fan when the values is within a second temperature zone.
**FIG. 3**

- Rotational speed (rpm)
- Temperature (°C)

**FIG. 4**

- Rotational speed (rpm)
- Temperature (°C)
A1 Detect temperature

A2 Determine temperature zone corresponding to detected temperature

A3 Calculate rotational speed corresponding to detected temperature based on mode set for specified temperature zone

A4 Control driving of fan corresponding to calculated rotational speed

End

FIG. 7
ELECTRONIC DEVICE AND FAN CONTROLLING METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/895,597, filed Oct. 25, 2013, the entire contents of which are incorporated herein by reference.

FIELD

[0002] Embodiments described herein relate generally to a technique of drive control of a fan, suitable for a personal electronic device such as a slim notebook computer or a tablet computer.

BACKGROUND

[0003] Recently, the number of relatively large but slim electronic devices such as tablet computers with a ten-inch touchscreen display has been increasing. Accordingly, a fan for heat dissipation also needs to be small and thin. To obtain sufficient airflow (with a smaller and thinner fan), the fan needs to run at high speed.

[0004] Here, the higher the rotational speed of the fan becomes, the larger the noise of the fan will become. In personal electronic devices, in particular, the noise needs to be reduced as much as possible. That is, the fan needs to be rotated at high speed in terms of heat dissipation, but the fan should also be rotated at low speed for noise reduction. As the fan becomes smaller and thinner, there is more demand than ever for realizing both heat dissipation and noise reduction at the same time.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] A general architecture that implements the various features of the embodiments will now be described with reference to the drawings. The drawings and the associated descriptions are provided to illustrate the embodiments and not to limit the scope of the invention.

[0006] FIG. 1 is an exemplary functional block diagram associated with fan control of an electronic device according to an embodiment.

[0007] FIG. 2 is an exemplary view for explaining typical conventional fan control.

[0008] FIG. 3 is an exemplary view for explaining fan control of the electronic device according to the embodiment.

[0009] FIG. 4 is an exemplary first view showing a process of change in rotational speed of a fan in a temperature zone between a lower limit and an upper limit in the electronic device according to the embodiment.

[0010] FIG. 5 is an exemplary second view showing a process of change in rotational speed of a fan in a temperature zone between a lower limit and an upper limit in the electronic device according to the embodiment.

[0011] FIG. 6 is an exemplary view for explaining fan control of the electronic device according to the embodiment when taking hysteresis control into consideration.

[0012] FIG. 7 is an exemplary flowchart showing fan control process of the electronic device according to the embodiment.

DETAILED DESCRIPTION

[0013] Various embodiments will be described hereinafter with reference to the accompanying drawings.

[0014] In general, according to one embodiment, an electronic device includes a fan, a temperature sensor and a controller. The temperature sensor is configured to output a value indicative of a detected temperature. The controller is configured to control a rotational speed of the fan. The controller is configured to keep the rotational speed of the fan constant when the value is within a first temperature zone or to change the rotational speed of the fan when the values is within a second temperature zone.

[0015] FIG. 1 is an exemplary functional block diagram associated with fan control of an electronic device 1 according to the present embodiment.

[0016] As shown in FIG. 1, the electronic device 1 such as a slim notebook computer or a tablet computer uses a fan 11 for active control of heat dissipation. Heat-producing devices such as a system-on-chip (SoC) 14, a memory 15, etc., are provided with temperature sensors 13a and 13b. Based on the temperatures detected by the temperature sensors 13a and 13b, a fan controller 12 controls driving of the fan 11. In the case of a personal computer for example, an embedded controller/keyboard controller (EC/KBC) or the like is used as the fan controller 12.

[0017] Also, the fan controller 12 stores setting information 121 for the drive control of the fan 11 in accordance with the temperatures detected (by the temperature sensors 13a and 13b). The setting information 121 includes a control point, a setting status of a mode for each temperature zone defined by the control point, an interpolation formula for calculating the rotational speed of the fan 11, etc., and the like, which will be described later.

[0018] Here, a typical conventional fan control will be explained with reference to FIG. 2 to facilitate understanding of the fan control in the electronic device 1 according to the present embodiment.

[0019] As shown in FIG. 2, in the conventional fan control, several control points (a1, a2, a3) which control the rotational speed of the fan are set to control the rotational speed of the fan to be constant in each temperature zone (temperature range).

[0020] More specifically, for example, when the temperature detected by the temperature sensor reaches control point a1, the fan is started to rotate at a low speed (low rotational speed). Then, the rotational speed of the fan is maintained as it is until the detected temperature reaches control point a2. That is, the rotational speed of the fan is constant within the temperature zone of which the lower-limit temperature is control point a1 and the upper-limit temperature is control point a2. When the detected temperature reaches control point a2, the rotational speed of the fan rises one step higher, for example, to a medium speed (medium rotational speed). This rotational speed is maintained until the detected temperature reaches control point a3. That is, the rotational speed of the fan is constant within the temperature zone of which the lower-limit temperature is control point a2 and the upper-limit temperature is control point a3. When the detected temperature reaches control point a3, the rotational speed of the fan further rises one step higher, for example, to a high speed (high rotational speed).

[0021] Note that, when the fan is rotated after the detected temperature exceeds control point a1, and then the temperature falls below control point a1 (because of heat dissipation
by the fan), usually the fan is still not stopped at this point. The fan is stopped at a point (control point a1') lower than control point a1 by a predetermined temperature (b of FIG. 2). Similarly, the timing when the rotational speed of the fan is dropped one step lower from the medium speed to the low speed is set to a point (control point a2') which is lower than control point a2 by the predetermined temperature. The timing when the rotational speed of the fan is dropped one step lower from the high speed to the medium speed is also set to a point (control point a3') which is lower than control point a3 by the predetermined temperature. This configuration is for hysteresis control to prevent the fan from repeatedly running/stopping and the rotational speed from repeatedly increasing/decreasing when the detected temperature rises and falls with respect to the control point. That is, the rotational speed of the fan is set when the detected temperature shifts from rising to falling or from falling to rising and if the difference between the previously detected temperature and the currently detected temperature exceeds the predetermined temperature difference. Also, the rotational speed during a time when the detected temperature is falling is set to the rotational speed associated with the temperature lower by the predetermined temperature with respect to the set rotational speed during a time when the detected temperature is rising.

However, this conventional fan control has disadvantage in reducing noise because the rotational speed of the fan is significantly changed when the detected temperature goes below the lower-limit temperature for the control point with the result that the noise of the fan is likely to draw user’s attention, etc.

Instead of setting control points to shift the rotational speed of the fan stepwise as mentioned above, there is also such a method to shift the rotational speed of the fan lineally in accordance with the detected temperature. However, this method cannot cope with a case where, for example, the fan needs to be rotated constantly at high speed (for example, maximum speed) for the sake of the protection of the device when the detected temperature is high.

In considering the above, the electronic device 1 according to the present embodiment is configured, as shown in FIG. 3, to set as to whether a mode to keep the rotational speed of the fan constant (first mode) or a mode to change the rotational speed according to temperature (second mode) is to be applied to each temperature zone (defined by the control point). In FIG. 3, the first mode is set within a temperature zone c4 and the second mode is set within temperature zones c1, c2 and c3.

Note that, as two temperature sensors 13a and 13b are illustrated in FIG. 1, a plurality of detected temperatures may be obtained and may have different values from each other. Usually, the temperature of the device producing the most heat is used as the temperature subjected to the control. However, it is also possible to consider such a method to calculate an average value by weighting each detected temperature.

Also, the second mode is further configured to set as to whether a linear mode or a curvilinear mode (non-linear mode) to be applied in a case where the detected temperature falls within the temperature zone between the upper-limit temperature and the lower-limit temperature, the linear mode configured to calculate the rotational speed of the fan corresponding to the detected temperature by using an interpolation formula to interpolate linearly between the rotational speed of the fan associated with the lower-limit temperature and that associated with the upper-limit temperature as shown in FIG. 4, and the curvilinear mode (non-linear mode) to calculate the rotational speed of the fan corresponding to the detected temperature by using an interpolation formula to interpolate curvilinearly (non-linearly) between the rotational speed of the fan associated with the lower-limit temperature and that associated with the upper-limit temperature as shown in FIG. 5. In FIG. 3, the linear mode is set within temperature zones c1 and c2 and the non-linear mode is set within temperature zone c3.

As shown in FIG. 4 and FIG. 5, the electronic device 1 according to the present embodiment does not change the rotational speed of the fan suddenly, and thus may reduce the noise of the fan less disturbing to the user. Also, when the rotational speed is curvilinearly interpolated as shown in FIG. 5, the rotational speed of the fan can be damped as a whole. For example, it is assumed that the detected temperature of frequently used application program A in operation rises to 40°C, and that of similar frequently used application program B in operation rises to 50°C. Also it is assumed that, accordingly, 40 and 50°C are set as the control points. Note that 40°C corresponds to 3,000 rpm and 50°C to 4,000 rpm in the examples shown in FIG. 4 and FIG. 5. In this case, within the lower end of the zone between 40 and 50°C, the heat produced by the execution of application program A is mainly taken care of, and thus the degree of elevation of the rotational speed of the fan can be moderated as shown in FIG. 5. When the detected temperature approaches 50°C (upper end of the zone), the rotational speed of the fan is raised relatively quickly to be ready for the execution of application program B and for the heat produced as a result of the execution.

As described above, the electronic device 1 according to the present embodiment is configured to set to each temperature zone as to whether the mode to keep the rotational speed of the fan constant or the mode to change the rotational speed of the temperature according to temperature, and further configured to set the manner of changing the rotational speed of the fan in the temperature zone between the lower limit and the upper limit as to how it should be changed. Thus, it is possible to realize flexible fan control both for heat dissipation and for noise reduction in the temperature zones mainly while operated by the user.

Incidentally, the hysteresis control was mentioned in connection with the conventional fan control as referring to FIG. 2, it is certainly possible for the electronic device 1 according to the present embodiment as well to perform fan control which takes the hysteresis control into account as shown in FIG. 6. That is, when the detected temperature rises above a control point d1, the rotational speed of the fan is controlled based on a mode set for the temperature zone of which the lower-limit temperature is control point D1. On the other hand, when the detected temperature is falling, the rotational speed is controlled based on a mode for the temperature zone of which the upper-limit temperature is set to control point d1 from a point (control point d1') which is lower than control point d1 by the predetermined temperature e of FIG. 6.

FIG. 7 is an exemplary flowchart showing fan control processes of the electronic device 1 according to the present embodiment.

Firstly, the temperature sensors 13a and 13b provided to heat-producing devices such as the SoC 14, the
memory 15 detect the temperature of each heat-producing device (block A). The fan controller 12 determines a temperature zone corresponding to the temperatures detected by the temperature sensors 13a and 13b (block A2) and calculates the rotational speed of the fan 11 corresponding to the detected temperatures based on a mode set for the specified temperature zone (block A3). Then, the fan controller 12 controls the driving of the fan 11 corresponding to the calculated rotational speed (block A4). By regularly repeating these processes, the fan control in accordance with temperature is realized.

[0032] As mentioned above, the electronic device 1 according to the present embodiment can set the operation mode of the fan 11 for each temperature zone, and then simultaneously realizes heat dissipation and noise reduction in the temperature zone mainly while operated by the user.

[0033] The various modules of the systems described herein can be implemented as software applications, hardware and/or software modules, or components on one or more computers, such as servers. While the various modules are illustrated separately, they may share some or all of the same underlying logic or code.

[0034] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

What is claimed is:

1. An electronic device comprising:
   a fan;
   a temperature sensor configured to output a value indicative of a detected temperature; and
   a controller configured to control a rotational speed of the fan,
   wherein the controller is configured to keep the rotational speed of the fan constant when the value is within a first temperature zone or to change the rotational speed of the fan when the values is within a second temperature zone.

2. The device of claim 1, wherein the controller is configured to calculate, when the value is in the second temperature zone, the rotational speed of the fan corresponding to a temperature between a lower-limit temperature and an upper-limit temperature based on a lower rotational speed associated with the lower-limit temperature of the second temperature zone and an upper rotational speed of the upper-limit of the second temperature zone.

3. The device of claim 2, wherein the controller is configured to calculate the rotational speed of the fan corresponding to the temperature between the lower-limit temperature and the upper-limit temperature by using an interpolation formula to interpolate the rotational speed of the fan linearly between the lower rotational speed and the upper rotational speed.

4. The device of claim 2, wherein the controller is configured to calculate the rotational speed of the fan corresponding to the temperature between the lower-limit temperature and the upper-limit temperature by using an interpolation formula to interpolate the rotational speed of the fan curvilinearly between the lower rotational speed and the upper rotational speed.

5. The device of claim 2, wherein the controller is configured to set whether a first interpolation formula or a second interpolation formula to calculate the rotational speed of the fan corresponding to the temperature between the lower-limit temperature and the upper-limit temperature, the first interpolation formula to interpolate the rotational speed of the fan linearly between a lower rotational speed of the fan associated with the lower-limit temperature and an upper rotational speed of the fan associated with the upper-limit temperature, and the second to interpolate the rotational speed of the fan curvilinearly between the lower rotational speed and the upper rotational speed.

6. The device of claim 1, wherein the controller is configured to set the rotational speed of the fan when the detected value detected by the temperature sensor shifts from rising to falling or from falling to rising, and when a difference between a previously detected temperature and a currently detected temperature exceeds a first value, and to set the rotational speed of the fan during a time when the detected value detected by the temperature sensor is falling, to the rotational speed of the fan associated with a second value which is reduced by the first value, as compared to the set rotational speed of the fan during a time when the detected value is rising.

7. A method of an electronic device, comprising:
   detecting a temperature; and
   controlling a rotational speed of a fan to keep the rotational speed of the fan constant when the detected temperature is within a first temperature zone or to change the rotational speed of the fan when the detected temperature is within a second temperature zone.

8. The method of claim 7, wherein the controlling comprises calculating, when the detected temperature is in the second temperature zone, the rotational speed of the fan corresponding to a temperature between a lower-limit temperature and an upper-limit temperature based on a lower rotational speed associated with the lower-limit of the second temperature zone and an upper rotational speed associated with the upper limit of the second temperature zone.

9. The method of claim 8, wherein the controlling comprises calculating the rotational speed of the fan corresponding to the temperature between the lower-limit temperature and the upper-limit temperature by using an interpolation formula to interpolate the rotational speed of the fan linearly between the lower rotational speed and the upper rotational speed.

10. The method of claim 8, wherein the controlling comprises calculating the rotational speed of the fan corresponding to the temperature between the lower-limit temperature and the upper-limit temperature by using an interpolation formula to interpolate the rotational speed of the fan curvilinearly between the upper rotational speed and the upper rotational speed.

11. The method of claim 8, wherein the controlling comprises determining whether a first interpolation formula or a second interpolation formula is to be used to calculate the rotational speed of the fan corresponding to the temperature between the lower-limit temperature and the upper-limit temperature in the second temperature zone, the first interpolation formula to interpolate the rotational speed of the fan.
linearly between the lower rotational speed and the upper rotational speed, and the second interpolation formula to interpolate the rotational speed of the fan curvilinearly between the lower rotational speed and the upper rotational speed.

12. The method of claim 7, wherein the controlling comprises setting the rotational speed of the fan when the detected temperature shifts from rising to falling or from falling to rising, and when a difference between a previously detected temperature and a currently detected temperature exceeds a first value, and setting the rotational speed of the fan during a time when the detected temperature is falling, to the rotational speed of the fan associated with a second value which is reduced by the first value, as compared to the set rotational speed of the fan during a time when the detected temperature is rising.

* * * * *