Control Technologies Utilized in the Cooling Fans

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1. Introduction

All types of information processing equipment including computers have become smaller in size, higher in density, faster in speed, and larger in capacity. All of these performance enhancements lead to an increase in heating.

Fans used to cool this equipment need to have a compact size and high cooling ability. This usually requires high-speed operation of the fans.

In order to meet these demands, today's fans need to be environmentally friendly including speed control to reduce noise levels and energy conservation during stand-by.

This document introduces the speed control technology in the cooling fan and the technology trends for the future.

2. Outline of Speed Control for Fans

The general driving circuit for a brushless DC fan is a very simple circuit which includes a rectifying function (instead of mechanical brushes) and the motor protection function for a locked rotor condition.

Below is the comparison of technology between the present and the future of the speed control circuit.

Table 1 Fan Speed Control - The Present and the Future

	Present Technology	Future Technology
Circuit Composition	・Use the function of IC for brushless DC fan drive	・Switching device + one chip / microcomputer
Control Method	・Control by adjusting off the time at phase switching ・Open loop control	・PWM method ・Closed loop control
Rotation Speed Accuracy	・± 10%	・± 5%
Interface	・Analog signal input (0V, power supply voltage, 0～5V, open etc.) ・Connect thermistor (outside fan, inside fan)	・Analog signal input (0V, power supply voltage, 0～5V, open etc.) ・Connect thermistor (outside fan, inside fan) ・Bi-directional communication the digital signal through I^2C bus, ISI bus

< The present technology >

The present drive circuit for the brushless DC fan makes use of a special purpose IC (integrated circuit). The IC provides for speed control – when to energize each winding, when to switch the phases, and torque reduction through OFF time control.

The control interface provides for an analog control signal input. This analog control signal is converted to a standard voltage level to adjust the length of the off time and is input into the IC as a control signal.

< The future technology >

The future speed control will be done with a PWM (Pulse Width Modulation) method by using a general-purpose one-chip microcomputer. A rotation speed signal is fed back to the microcomputer. This speed feedback is used to provide closed-loop speed control with corresponding improvement in speed accuracy. A serial interface for the control is also provided with this future fan.

3. The Present Technology — Control by Energizing Off Time Adjustment —

Fig.1 shows the block diagram of the IC for driving the fan.

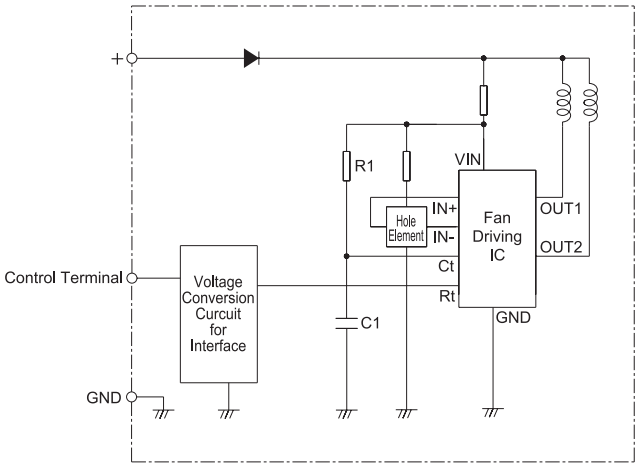

Fig.1 Energizing Off Time Adjustment Control Block Diagram

Fig.2 shows the timing chart during control.[(1)]

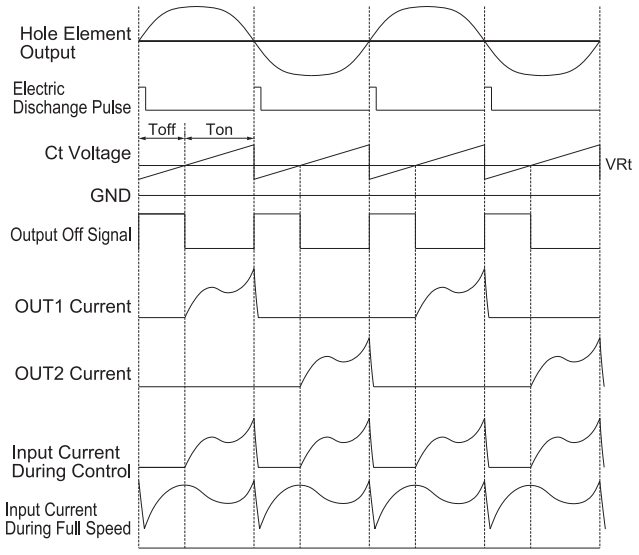

Fig.2 Timing Chart During Control

The rotation speed is determined by setting the charging time of Ct voltage according to the time constant of R1 and C1. Comparison with voltage VRt determines the Toff time.

Speed may be controlled in a linear fashion by using the external signal to set the voltage VRt. The external control signal is made up of the analog voltage and/or the thermister terminal voltage.

The features of this control method are as follows.

(1) The circuit is simple
(2) Losses in the power element are small
(3) High reliability
(4) An additional circuit that prevents the switching sound is necessary
(5) Accuracy of the rotation speed is ±10%

Table 2 shows the examples of the application model.

Table 2 Application Model

Application model	Control Specifications
2 speed fan	・Analog input to control terminal During 0V : low speed rotation Power supply voltage : high speed rotation
Thermally speed controlled fan	・Connect the thermistor (outside fan, inside fan) Set temperature below ① : low speed rotation Set temperature higher than ② : high speed rotation Change to linear between ① and ②
Voltage control fan	・Analog input to control terminal During 0V : low speed rotation During 5V : high speed rotation Change to linear between 0～5V

4. The Future Technology — Closed Loop PWM Control by Microcomputer —

Fig.3 shows the block diagram of the control circuit.

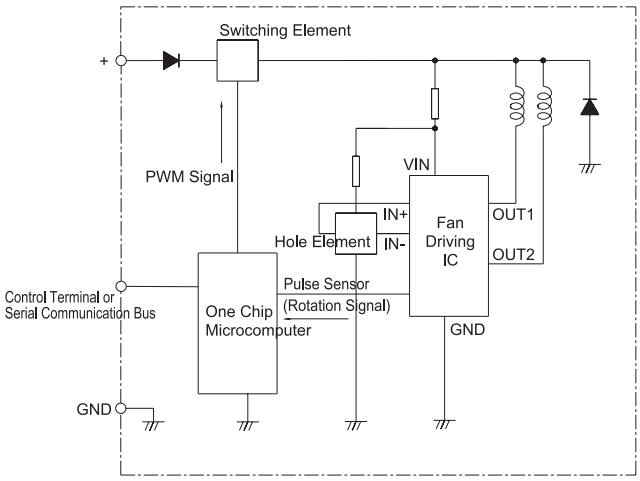

Fig.3 PWM Control by Microcomputer Block Diagram

Fig.4 shows the timing chart during control.

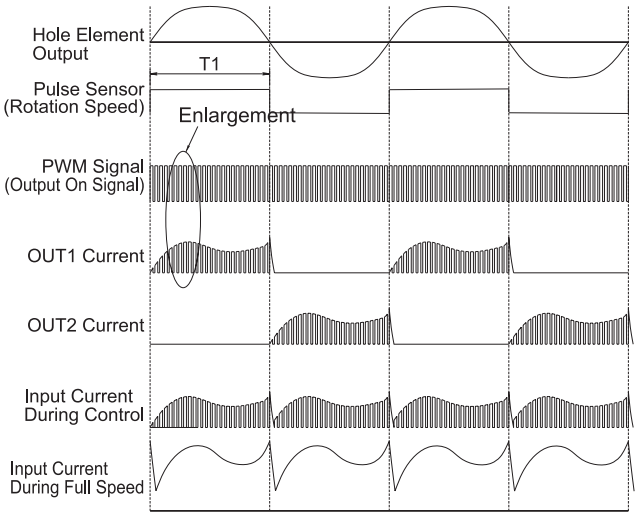

Fig.4 The Timing Chart During Control

The rotation speed is detected by adopting the one-chip microcomputer with the PWM function, and counting cycle T1 of the pulse sensor (two pulses/rotation). The rotation speed is fed back to the control algorithm and compared with the requested number of set rotations at all times in order to adjust the on-cycle of the switching element. Fig.5 shows that the rotation speed can be controlled since the OUT1 current peak value (and the torque from winding energization) becomes smaller as the duty ratio of the PWM signal becomes smaller.

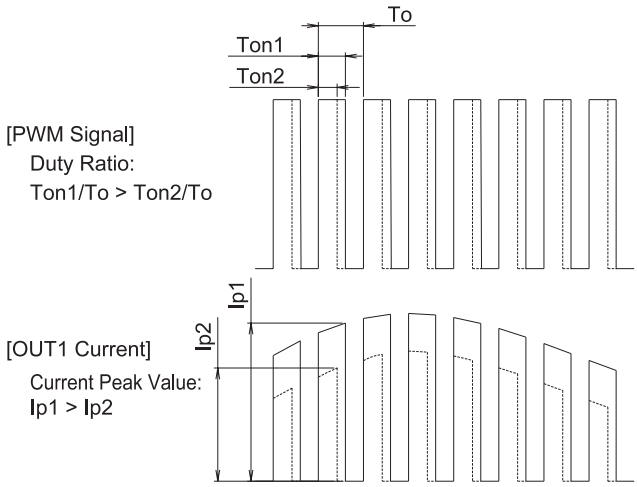

Fig.5 PWM Signal and Output Current

The features of this control method are as follows.

(1) Accuracy of the rotation speed is high. ±5% or less.
(2) It is possible to handle various interfaces.
(3) PWM frequency is set to avoid audio frequencies so the switching sound is low.
(4) Losses in the power element are large.
(5) The cost of the materials of the circuit part is high.

5. Advantages of Using the Microcomputer Control

General-purpose microcomputers with the desired functions have dramatically increased in volume. The corresponding decrease in price has allowed us to utilize them in cooling fans with an increase in fan functionality. Advantages of using the microcomputer control are introduced as follows.

(1) The CPU in the device being cooled can communicate directly with the fan using the serial communication bus (I^2C bus and ISI bus).
(2) The device being cooled can use the serial interface to determine important information about the fan such as serial number, production lot number, manufacturer, etc.
(3) The device being cooled can use the serial interface to control the fan speed in any way (including even complex speed control). The device can also monitor fan speed and other fan status information.

Therefore, the microcomputer control of the fan is not only superior in speed control but the serial interface has made possible new features not possible with conventional fan technology.

The details are introduced in the new product introduction, “Program Control Fan”, in this technical report.

6. Conclusion

When designing a device that uses 10 fans or more, we use a separate control board and control the fan individually to confirm the state of fan operation, to adjust the air-flow depending on the layout, and to keep up with other urgent design needs. The control of the cooling fan is able to handle more and more delicate and flexible needs without a control board thanks to the use of the communication control provided by the microcomputer introduced in this document. This is due to the fact that the system directly sends the command to the fan and it controls the rotation speed accurately according to the instruction. In the future, if the miniaturization and the reduction in costs of the microcomputer advance even further, it will become possible to control the MPU cooler and the system fan installed in the PC directly by the PC.

Reference

(1) SANYO Electric Co., Ltd.:“LB1860,1860M,1861,1861M speed controlled fan motor driver”, Sanyo Semiconductor News No.3519A

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Joined company in 1984
Cooling Systems Division, Design Dept.
Worked on the development and the design of the fan motor