"Program Control Fan"

Naruhiko Kudou　Masato Murata　Munenori Takakuwa　Yasuhiro Maruyama

1. Introduction

The function and performance level of various information systems is improving and demands on the cooling fan functionality are also increasing. For example, there is a demand for fans with the ability to be controlled by the device being cooled. This includes the rotation speed control to improve efficiency of devices with multiple cooling fans.

To satisfy such demands, we have developed the "Program Control Fan", which has a multifunctional communication control for the BLDC fan and high accuracy rotational speed control.

This paper introduces the features and the outline of this new product.

2. Background of the Development

We have been putting various speed-controlled fans on the market in order to meet the customer demand for improved functionality of their systems through fan speed control. However, the customer demands are increasing in diversity and are changing more rapidly than ever before.

Moreover, most of the conventional speed-controlled fans were using the voltage or current change as an instruction method for the rotation speed. This technology does not allow bi-directional communication as in serial communication.

Therefore, we installed a small-size CPU inside the motor control circuit for certain fans (ϕ172mm x 51mm thickness and 120mm sq. x 38mm thickness) which are often used to cool information technology devices. Now we achieved bi-directional communication and high accuracy speed control.

3. Features of "Program Control Fan"

"Program control fan" (hereafter, this product) is able to control the fan by using two kinds of interface specifications, I²C (Inter Integrated Circuit) and ISI (Inter-locked Serial Interface). The following are the features of this product.

(1) The rotation speed of the fan can be arbitrarily set from 500min^{-1} or more to the rated rotating speed with any step of 10min^{-1}. Therefore, the fan is able to rotate while avoiding any resonance generated when the fan is installed on the device.

(2) More detailed information inside the fan can be obtained than that of the conventional fan with a sensor. Additionally, the rotation speed and the state of the fan can be checked in real time by communicating bi-directionally with the device.

(3) Use of the PWM control for the speed control of the fan reduces switching noise and produces smooth and low noise speed control.

(4) The accuracy of the rotation speed can be controlled within ±5% by feedback control. Moreover, the overall static pressure property has improved as compared with that of the conventional fan because the rotation speed can be kept constant even if load is added to the fan. In addition, the sound of the rotation speed variation generated when multiple numbers of fans are installed in the device can be decreased.

(5) A manufacturing date and individual information can be stored in the fan when it is shipped and certain information can be read from the fan if necessary.

(6) With the I²C specification, a maximum of 16 fans can be controlled on the same signal line.

(7) Changes in the multiple fan control strategy can now be accomplished with communication changes instead of control circuit changes. This increases the flexibility and reduces the time to make any changes – all thanks to the small-size CPU used for fan control.

4. Structure of the "Program Control Fan"

Fig.1 shows the structure of this product.

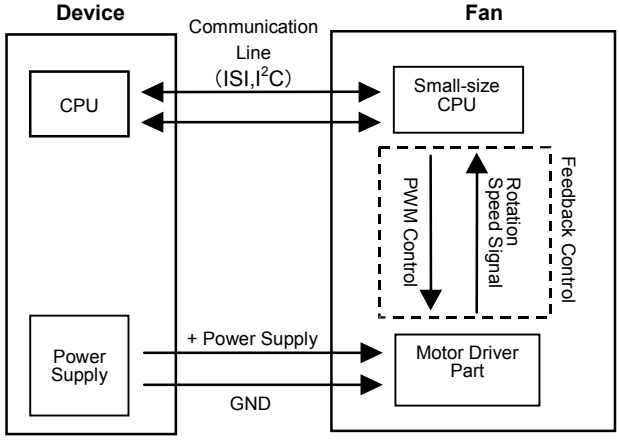


Fig.1 Structure of the "Program Control Fan"

The device and the fan are connected with two power supply lines and two communication lines (besides this, three address lines are necessary for I²C). The power supply line provides power to the motor driver part as the conventional fan did. The communication line takes charge of delivering and receiving data between the device and fan using serial communication. The CPU in the

fan receives and analyzes the command from the device and transmits the response.

The small-size CPU inside the fan monitors the rotation speed signal from the motor driver part in order to provide highly accurate rotation speed control and to protect the motor in case the fan is locked.

The development environment of this product is shown in Fig.2 as an example.

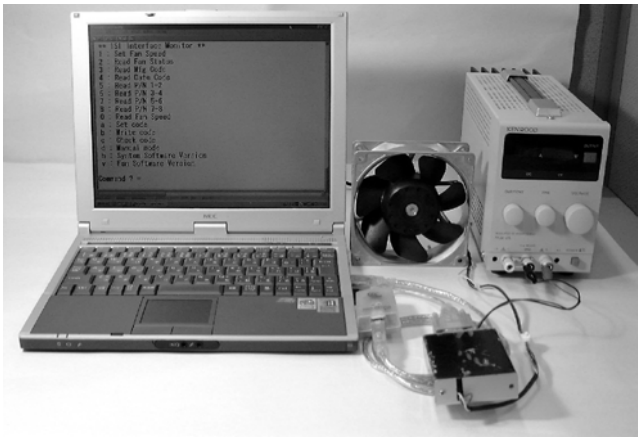


Fig.2 The Development Environment of the "Program Control Fan"

In Fig.2, the black box in the lower right represents the device CPU that creates and transmits the command and receives the response. The notebook personal computer is used as a monitor for command input and response check. Next, the block diagram of the development environment is shown in Fig.3.

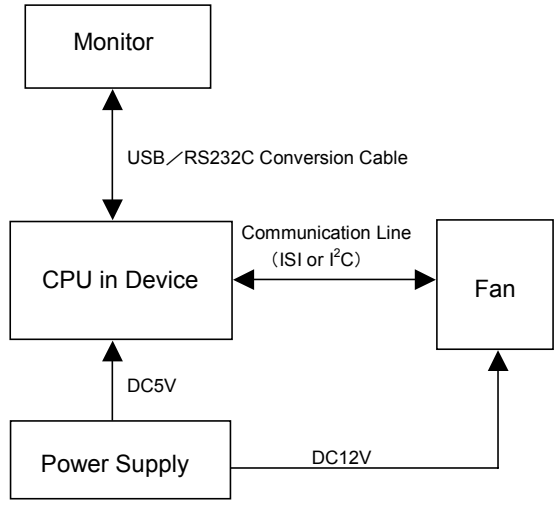


Fig.3 Block Diagram of the Development Environment

5. Interface

5.1 Command/Response

The communication protocol of ISI and I²C uses the command response system, which performs the communication by transmitting the command from the device to the fan and also the response corresponding to the command from the fan to the device. Table 1 shows the command/response list.

Table 1 Command/Response List

Command (Device→Fan)	Response (Fan→Device)
Rotation Speed Setting	Normal (Obtained the rotation speed data without problem)
	Abnormal (Rotation speed trouble)
Rotation Speed Reading	Current Rotation Speed
Fan State Reading	Normal (Fan rotates at set speed)
	Right After Fan Started (Speed not set)
	Abnormal (Out of the set speed)
Fan Individual Information Reading	Individual Information of the Fan

5.2 ISI Interface Specifications

There are currently two kinds of interface specifications for this product, I²C and ISI. I²C is already widespread in the market so we will not provide an explanation of I²C in this paper. ISI is a type of serial interface that can easily receive and send data while using only two signal lines (in the same way as I²C while confirming transmission and reception every 1bit). Fig.4 shows the ISI communication sequence.

6. Characteristics of the "Program Control Fan"

6.1 General Characteristics

Table 2 shows the general characteristic of the "Program control fan" in the ϕ172mm x 51mm thickness and 120mm sq. x 38mm thickness fans.

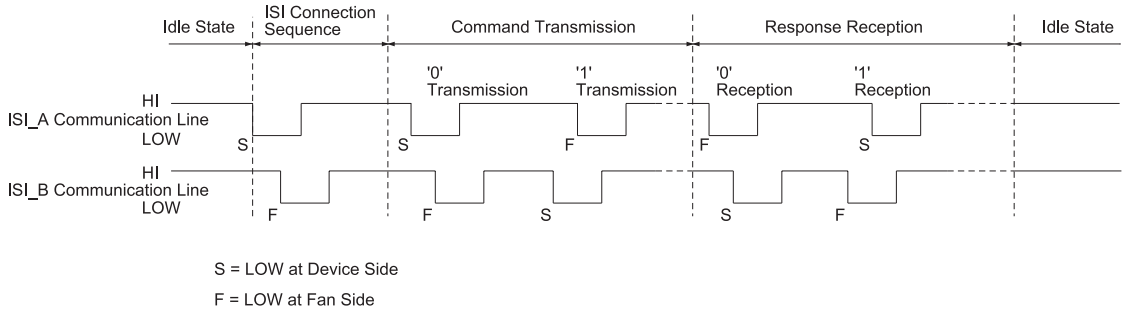


Fig.4 ISI Communication Sequence

Table 2 General Characteristics

"120mm sq. × 38mm thickness fan"

Model	Interface Spec.	Rated Voltage (V)	Voltage Range (V)	Rotation Speed (min^{-1})	Rated Current (A)	Rated Input (W)	Max. Air Volume (m^3/min)	Max. Static Pressure (Pa[mmAq])	Noise (dB)	Mass (g)
9GL1212PA1J01	ISI	12	10.2～13.8	4800 *1	1.9	22.8	5.2	230	57	370
				3800 *2	1.1	13.2	4.1	185	50	
9GL1212PB1J01	I^2C			4800 *1	1.9	22.8	5.2	230	57	
				3800 *2	1.1	13.2	4.1	185	50	

" ϕ172mm × 51mm thickness"

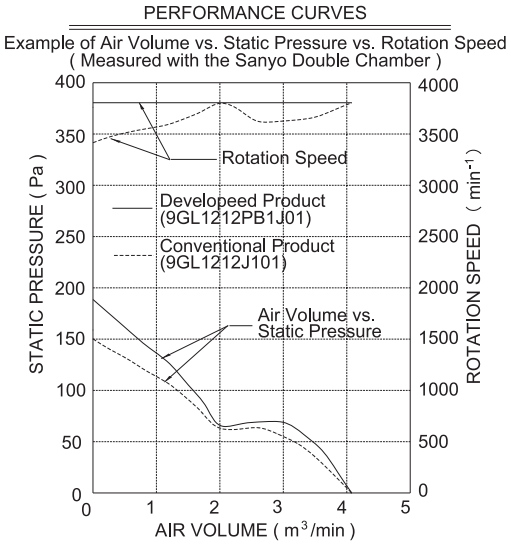
Model	Interface Spec.	Rated Voltage (V)	Voltage Range (V)	Rotation Speed (min^{-1})	Rated Current (A)	Rated Input (W)	Max. Air Volume (m^3/min)	Max. Static Pressure (Pa[mmAq])	Noise (dB)	Mass (g)
109E5712PA5K01	ISI	12	10.2～13.8	4100 *1	2.9	34.8	8.5	243	60	760
				3200 *2	1.55	18.6	6.5	220	54	
109E5712PB5K01	I^2C			4100 *1	2.9	34.8	8.5	243	60	
				3200 *2	1.55	18.6	6.5	220	54	

*1 is the rated rotation speed with no load on the fan.

*2 is the maximum rotation speed the "program control fan" is able to control with the maximum static pressure.

6.2 Air Volume - Static Pressure

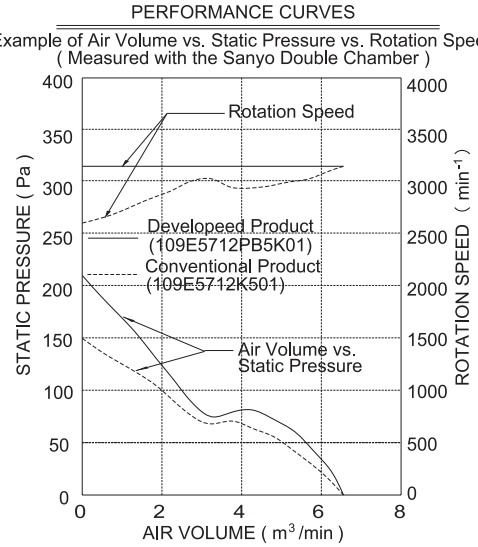
Fig.5 shows the comparison example of air volume versus static pressure between the conventional 120mm sq. x 38mm thickness fan and this product.



Note: This characteristic was measured at the maximum speed the "program control fan" is able to control with the maximum static pressure.

Fig.5 Comparison Example of Air Volume – Static Pressure (120mm sq. x 38mm thickness)

Next, Fig.6 shows the comparison example of air volume versus static pressure between the conventional ϕ172mm x 51mm thickness fan and this product.



Note: This characteristic was measured at the maximum speed the "program control fan" is able to control with the maximum static pressure.

Fig.6 Comparison Example of Air Volume – Static Pressure (ϕ172mm x 51mm thickness)

7. Conclusion

Some of the features and the performance of the newly developed "program control fan" were introduced here. Functions and performance of various information devices will continuously improve and the wide variety of demands such as the integration of the internal communications, the device control in remote places, and the individual rotation speed control of the multiple fan applications to improve heat exchange efficiency will also continuously increase.

In such situations, this newly developed product is not only highly functional but also useful in many ways and the further expansion of the fan market can be expected.

We intend to expand this technology into fans of other sizes and to increase the types of communication interfaces in order to enrich the lineup of this product in the future.

Naruhiko Kudou

Joined company in 1997
Cooling Systems Division, Design Dept.
Worked on the development and design of fan motor after experiencing the production engineering

Masato Murata

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

Munenori Takakuwa

Joined company in 1998
Cooling Systems Division, Design Dept.
Worked on the development and design of fan motor

Yasuhiro Maruyama

Joined company in 2001
Cooling Systems Division, Design Dept.
Worked on the development and design of fan motor