F75387SG/RG Datasheet

±1°C Accuracy H/W Monitor IC with Automatic Fan Speed Control

Release Date: July, 2007
Revision: V0.27P

F75387 Datasheet Revision History

Version	Date	Page	Revision History
0.20P	Mar/2005	-	Preliminary Release Version.
0.21P	Mar/2005	41-42	Update DC spec
0.22P	Apr/2005	37~40	Update description of Index A4~A8/B4~B8
0.23P	May/2005	48	Update application circuit
0.24P	Jun/2005	41,42	Update DC Spec
0.25P	Dec/2005		Revised the typo
0.26P	Dec/2006	4	Add Taiwan patent certification number
0.27P	July/2007	-	Company readdress

Please note that all data and specifications are subject to change without notice. All the trade marks of products and companies mentioned in this data sheet belong to their respective owners.

LIFE SUPPORT APPLICATIONS

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury.   Customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Fintek for any damages resulting from such improper use or sales.

F75387

Table of Contents

July, 2007
0.27P

1. General Description

F75387 is a system hardware monitoring and automatic fan speed controlling IC specific designed for graphic cards and PC etc. The F75387 can monitor several critical hardware parameters of the system, including voltages, temperatures and fan speeds which are very important for the system to work stably and properly.

An 11-bit analog-to-digital converter (ADC) was built inside F75387. The chip can monitor up to 4 analog voltage inputs, 2 fan tachometer inputs and 3 temperature inputs (2 remote and 1 local sensor). The remote temperature sensor can be performed by thermistor, transistor 2N3906 and CPU/GPU thermal diode. The F75387 can provide automatic fan speed control so that the system can operate at the minimum acoustic noise. This chip supports not only PWM duty mode (PWMOUT) but also linear mode (DACOUT 0 ~ 3.3V) for fan speed control. Internal oscillator was built in this chip and user can use external clock input if users need accurate fan speed count. Also the users can set up the upper and lower limits (alarm thresholds) of all monitored parameters and the F75387 can also issue warning messages for system protection when there is something wrong with monitored items.

Through the BIOS or application software, the users can read all the monitored parameters of system all the time. And a pop-up warning can be also activated when the monitored item was out of the proper/pre-setting range. The F75387 is in the package of 16-pin SOP/SSOP and powered by 3.3V

2. Features

- 4 voltage inputs
- Provide 2 remote and 1 on-chip local temperature sensor
- Up to 2 fan speed monitoring inputs and 2 automatic fan speed control
- Power on fan speed configuration
  - 100% or 60% PWM duty cycle output on initial
  - 3.3V or 1.98V DAC linear voltage output on initial
- Provide up to 4 system protection signals
  - OVT#, SMI#, FAN_FAULT#, VOLT_FAULT# signals
- Programmable limited and setting points(alert threshold) for all monitored items
- 2-wire SMBus interface
- V_{CC}3V operation and 16-SOP/SSOP package(150mil)

Noted: Patented TW207103 TW207104 TW220442 US6788131 B1 TW235231 TWI263788

3. Key Specifications

- Supply Voltage   3.0V to 3.6V
- Measured Range $0 \sim 145\ ^{o}C$
- Remote Diode Temperature Accuracy $\pm1^{o}C$ from $+60^{o}C$ to $+100^{o}C$
- Local Temperature Accuracy $\pm3^{o}C$ from $+60^{o}C$ to $+100^{o}C$

4. Pin Configuration

FANIN1	1	16 VCC
GPIO0/FANIN2/VOLT_FAULT#	2	15 D1+
PWM1/DAC1/ADDR_TRAP	3	14 D2+
GPIO1/PWM2/DAC2/FAN_FAULT#	4	13 VREF
GPIO2/SMI#/FAN_FAULT#/LED	5	12 VIN1
OVT#/VOLT_FAULT#/GPIO3/CLKIN	6	11 VIN2
SCLK	7	10 VIN3
SDATA	8	9 GND

5. Pin Description

I/OOD_{12t} - TTL level bi-directional pin, can select to OD or OUT by register, with 12 mA source-sink capability.

I/OOD_{16t} - TTL level bi-directional pin, can select to OD or OUT by register, with 16 mA source-sink capability.

I/OD_{12ts5V} - TTL level bi-directional pin and schmitt trigger, Open-drain output with 12 mA sink capability, 5V tolerance.

I/O_{8t} - TTL level bi-directional pin with 8 mA sink capability.

$I/O_{8t\text{-}u47,5V}$ - TTL level bi-directional pin with 8 mA sink capability, pull-up 47k ohms, 5V tolerance.

I/O_{12ts5V} - TTL level bi-directional pin and schmitt trigger with 12 mA sink capability, 5V tolerance.

O_{12} - Output pin with 12 mA source-sink capability.

AOUT   - Output pin(Analog).

OD_{12} - Open-drain output pin with 12 mA sink capability.

IN_{ts5V} - TTL level input pin and schmitt trigger, 5V tolerance.

AIN   - Input pin(Analog).

P   - Power.

5.1. Power Pin

Pin No.	Pin Name	Type	Description
16	VCC	P	3.3V power supply voltage input
9	GND(D-)	P	GND(If sensing CPU/GPU thermal diode or transistor 3906, please connect D- to this pin. Refer to application circuit)

5.2. Monitoring Items and Fan Speed Control

Pin No.	Pin Name	Type	Description
1	FANIN1	IN_{ts5v}	0V to +3.3V amplitude fan tachometer input.
2	GPIO0(Default)	IN_{ts5v}/OD_{12}	General purpose I/O pin. Default Open drain
	FANIN2	IN_{ts5v}	0V to +3.3V amplitude fan tachometer input.
	VOLT_FAULT#	OD_{12}	This pin will be a logic **LOW** when the voltage exceeds its limit.
3	PWM1(Default)	OOD_{12}	Use PWM duty cycle to control fan1 speed.
	DAC1	AOUT	Use linear voltage output (0~3.3V) to control fan1 speed.
	ADDR_TRAP	IN_{ts5v}	Address power on trapping pin. Internal weak pull down. The internal pull-down resistor will be turn-off after power-on trapping. For detail description, please see register description index01h
4	GPIO1(Default)	IN_{ts5v}/OD_{12}	General purpose I/O pin. Default Open drain
	PWM2	OOD_{12}	Use PWM duty cycle to control fan2 speed.
	DAC2	AOUT	Use linear voltage output (0~3.3V) to control fan2 speed.
	FAN_FAULT#	OD_{12}	This pin will be a logic **LOW** when the fan speed is abnormal.
10	VIN3	AIN	0V to 2.048V FSR Analog Inputs
11	VIN2	AIN	0V to 2.048V FSR Analog Inputs
12	VIN1	AIN	0V to 2.048V FSR Analog Inputs
14	D2+	AIN	Thermistor / transistor 2N3906/ CPU/GPU thermal diode terminal input
15	D1+	AIN	Thermistor / transistor 2N3906/ CPU/GPU thermal diode terminal input

5.3. Alert Signals and Others

Pin No.	Pin Name	Type	Description
5	GPIO2(Default)	IN_{ts5v}/OD_{12}	General purpose I/O function. Default pure open drain
	SMI#	OD_{12}	System management interrupt (Pure open drain). This pin will be active low when there is something wrong with voltage, temperature and fan. See register description index 33h
	VOLT_FAULT#	OD_{12}	Active-Low output. This pin will be a logic **LOW** when the voltage exceeds its limit.

6	OVT#(Default)	OD_{12}	Default open drain active-low output. This pin will be a logic **LOW** when the temperature exceeds its limit. Default output enable when the temperature exceeds $100^{o}C$ on initial.
	GPIO3	IN_{ts5v}/OD_{12}	General purpose I/O function.
	FAN_FAULT#	OD_{12}	This pin will be a logic **LOW** when the fan speed is abnormal.
	CLKIN	IN_{ts5v}	24MHz/48MHz external clock input for chip operation source. When input external clock, the fan speed count will be more accurate.
13	VREF	AOUT	Reference voltage 2.304V.
8	SDATA	IN_{ts5v}/OD_{12}	Serial bus data
7	SCLK	IN_{ts5v}	Serial bus clock

6. Function Description

6.1. General Description

F75387 is a system hardware monitoring and automatic fan speed controlling IC specific designed for graphic cards and PC etc. An 11-bit analog-to-digital converter (ADC) was built inside F75387. The chip can monitor up to 4 analog voltage inputs, 2 fan tachometer inputs and 3 temperature inputs (2 remote and 1 local sensor). The remote temperature sensor can be performed by thermistor, transistor 2N3906 and CPU/GPU thermal diode. The F75387 can provide automatic fan speed control so that the system can operate at the minimum acoustic noise. This chip supports not only PWM duty mode (PWMOUT) but also linear mode (DACOUT) for fan speed control. Also the users can set up the upper and lower limits (alarm thresholds) of all monitored parameters and the F75387 can also issue warning messages for system protection when there is something wrong with monitored items.

6.2. Analog Inputs

For the 11-bit ADC has the 8mv LSB, the maximum input voltage of the analog pin is 2.048V. Therefore the voltage under 2.048V (ex:1.5V) can be directly connected to these analog inputs. The voltage higher than 2.048V should be reduced by a factor with external resistors so as to obtain the input range. Only 3Vcc is an exception for it is main power of the F75387. Therefore 3Vcc can directly connect to this chip's power pin and need no external resistors. There are two functions in this pin with 3.3V. The first function is to supply internal analog power of the F75387 and the second function is that this voltage with 3.3V is connected to internal serial resistors to monitor the +3.3V voltage. The internal serial resistors are two 150K ohm, so that the internal reduced voltage is half of +3.3V.

There are four voltage inputs in the F75387 and the voltage divided formula is shown as follows:

$$VIN = V_{+12V} \times \frac{R_2}{R_1 + R_2}$$

where V_{+12V} is the analog input voltage, for example.

If we choose R1=27K, R2=5.1K, the exact input voltage for V_{+12v} will be 1.907V, which is within the tolerance.
As for application circuit, it can be refer to the figure as follows.
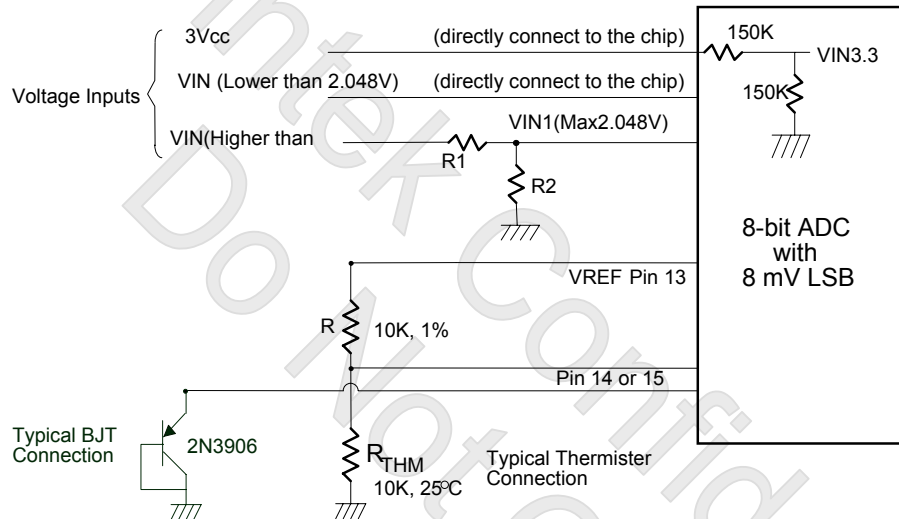
Figure 6-1

6.3. Access Interface and Power On Configuration

The F75387 provides one serial access interface, Serial Bus, to read/write internal registers. The address of Serial Bus is configurable by using power-on trapping. The pin 3 (PWM1/DAC1/ADDR_TRAP) is a multi-function pin. During power-on, this pin serves as input detection of logic high or logic low. Two Serial Bus address 0x5A (0101_1010) and   0x5C (0101_1100) can be selected by changing external pull-up resistors. Following table indicates the configuration:

External Resistor	NC	200K	10K	2.2K
Address	0x5A	0x5C	0x5C	0x5A
Power On PWM Duty Cycle/DAC Linear Voltage Output	60% x 3VCC	100% x 3VCC	60% Duty Cycle	100% Duty Cycle
Power On DACOUT/PWMOUT Mode	DACOUT	DACOUT	PWMOUT	PWMOUT

(a) *Serial bus write to internal address register followed by the data byte*

Serial Bus Write to Internal Address Register followed by the Data Byte
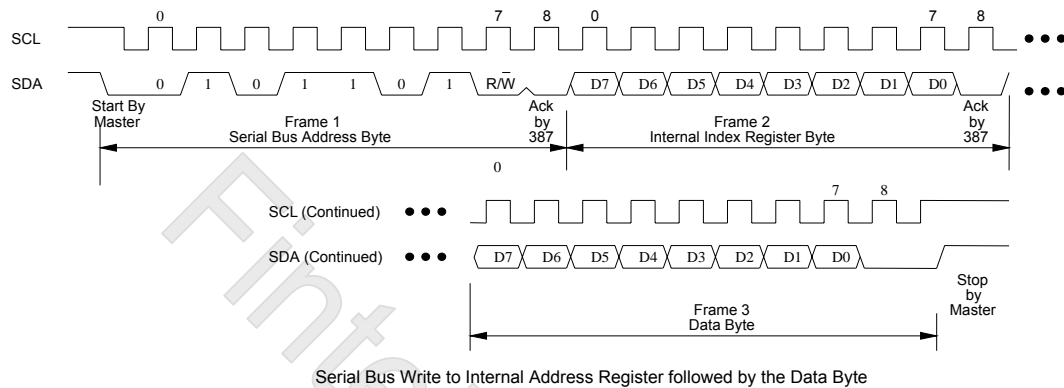
(b) **Serial bus read form internal address register followed by the data byte**

Serial Bus read from Internal Address Register followed by the Data Byte
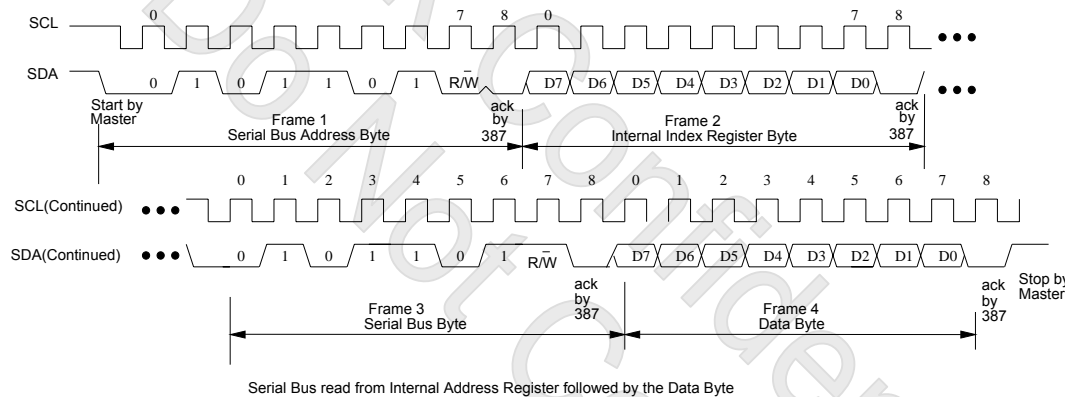
6.4. Typical operating characteristic
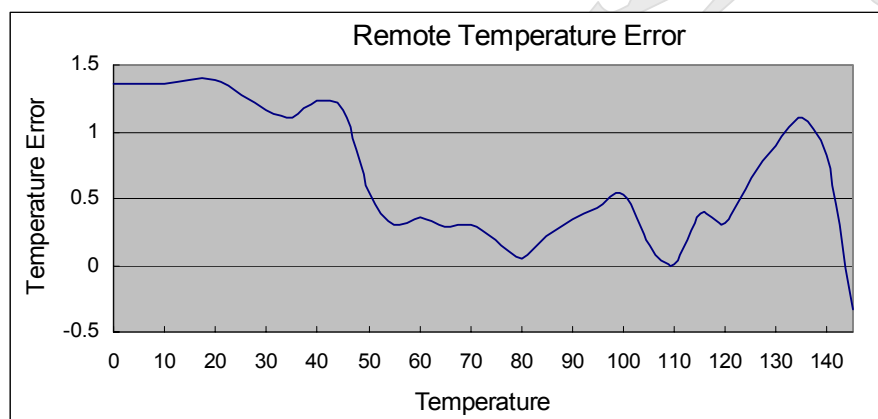
6.5. Temperature monitoring

The F75387 monitors a local and a remote temperature sensor. Both can be measured from 0°C to 140.875°C.

The temperature format is as the following table:

July, 2007
0.27P

Temperature (High Byte)	Digital Output	Temperature (Low Byte)	Digital Output
0°C	0000 0000	0°C	000 0 0000
1°C	0000 0001	0.125°C	001 0 0000
25°C	0001 1001	0.250°C	010 0 0000
50°C	0011 0010	0.375°C	011 0 0000
75°C	0100 1011	0.500°C	100 0 0000
90°C	0101 1010	0.625°C	101 0 0000
100°C	0110 0100	0.750°C	110 0 0000
140°C	1000 1100	0.875°C	111 0 0000

Remote-sensor transistor manufacturers

Manufacturer	Model Number
Panasonic	2SB0709 2N3906
Philips	PMBT3906

6.6. Temperature Measurement Machine

The temperature data format is 11-bit unsigned for thermal sensor. The 8-bit temperature data can be obtained by reading through two registers. The format of the temperature data is as below

Temperature	8-Bit Digital Output	
	11-Bit Binary	11-Bit Hex
+125.5°C	0111,1101.100	7D.8h
+25.125°C	0001,1001.001	19.2h
+2.875°C	0000,0010.111	02.Eh
+1.25°C	0000,0001.010	01.4h
+0.0°C	0000,0000	00.0h

6.7. Monitor Temperature from thermistor

The F75387 can connect two thermistors to measure environment temperature or remote temperature. The specification of thermistor should be considered to (1) β value is 3435K (2) resistor value is 10K ohm at 25°C. In the Figure 6-1, the thermistor is connected by a serial resistor with 10K ohm, then connected to VREF (pin13).

6.8. Monitor Temperature from thermal diode

Also, if the CPU, GPU or external circuits provide thermal diode for temperature measurement, the F75387 is capable to these situations. The build-in reference table is for PNP 2N3906 transistor, and each different kind of thermal diode should be matched with specific and BJT gain. In the Figure 6-1, the transistor is directly connected into temperature pins. For detail, please refer to application circuit.

6.9. ADC Noise Filtering

The ADC is integrating type with inherently good noise rejection. Micro-power operation places constraints on high-frequency noise rejection; therefore, careful PCB board layout and suitable external filtering are required for high-accuracy remote measurement in electronically noisy environment. High frequency EMI is best filtered at CPU/GPU D+ and D-(connect to pin 9 GND) with an external 3300pF capacitor. Too high capacitance may introduce errors due to the rise time of the switched current source. Nearly all noise sources tested cause the ADC measurement to be higher than the actual temperature, depending on the frequency and amplitude.

6.10. Over Temperature Signal (OVT#)

The F75387 can provide two external thermal sensors to detect temperature. Two types of OVT# are supported.
1. When monitored temperature exceeds the over-temperature threshold value, OVT# will be asserted until the temperature goes below the hysteresis temperature.
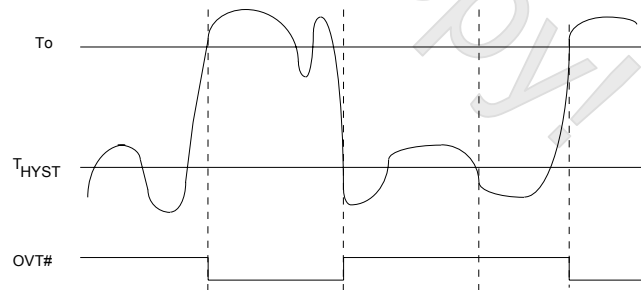
2. When monitored temperature is not in the target range for the queue time, OVT# will be asserted until the temperature goes into the target range for the queue time.
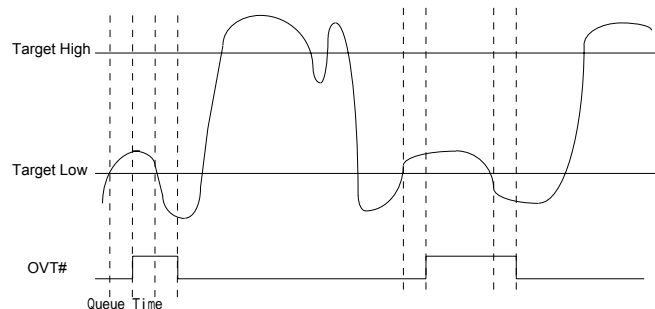
6.11. Fan Speed Monitoring and Control

Fan speed count

Inputs are provided by the signals from fans equipped with tachometer outputs. The level of these signals should be set to TTL level, and maximum input voltage cannot be over 5V. If the input signals from the tachometer outputs are over the 5V, the external trimming circuit should be added to reduce the voltage to obtain the input specification. The normal circuit and trimming circuits are shown below:

Fan with Tach Pull-Up to +12V, or Totern-Pole Output and Register Attenuator

Fan with Tach Pull-Up to +12V, or Totem-Pole Putput and Zener Clamp

Fan with Tach Pull-Up to +5V, or Totern-Pole Output and Register Attenuator

Fan with Tach Pull-Up to +5V, or Totem-Pole Putput and Zener Clamp
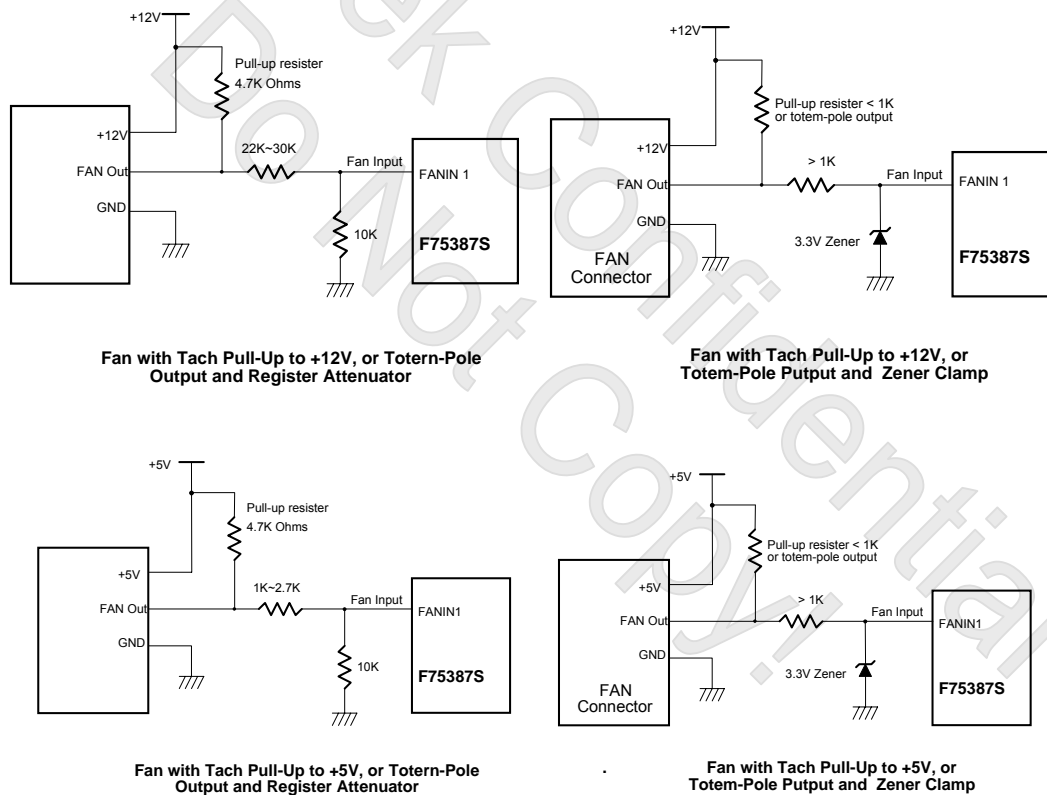
Determine the fan counter according to:

$$Count = \frac{1.5 \times 10^6}{RPM}$$

In other words, the fan speed counter has been read from register, the fan speed can be evaluated by the following equation. As for fan, it would be best to use 2 pulses tachometer output per round.

$$RPM = \frac{1.5 \times 10^6}{Count}$$

Fan speed control

The F75387 provides 2 fan speed control methods: 1. LINEAR FAN CONTROL   2. PWM DUTY CYCLE

Linear Fan Control

The range of DC output is 0~3.3V, controlled by 8-bit register (CR75 for FAN1 and CR85 for FAN2). 1 LSB is about 0.013V. The output DC voltage is amplified by external OP circuit, thus to reach maximum FAN OPERATION VOLTAGE, 12V. The output voltage will be given as followed:

$$Output\_voltage\ (V) = 3.3 \times \frac{Programmed\ 8 \text{-} bit\ Register\ Value}{255}$$

And the suggested application circuit for linear fac control would be:

DC FAN Control with OP
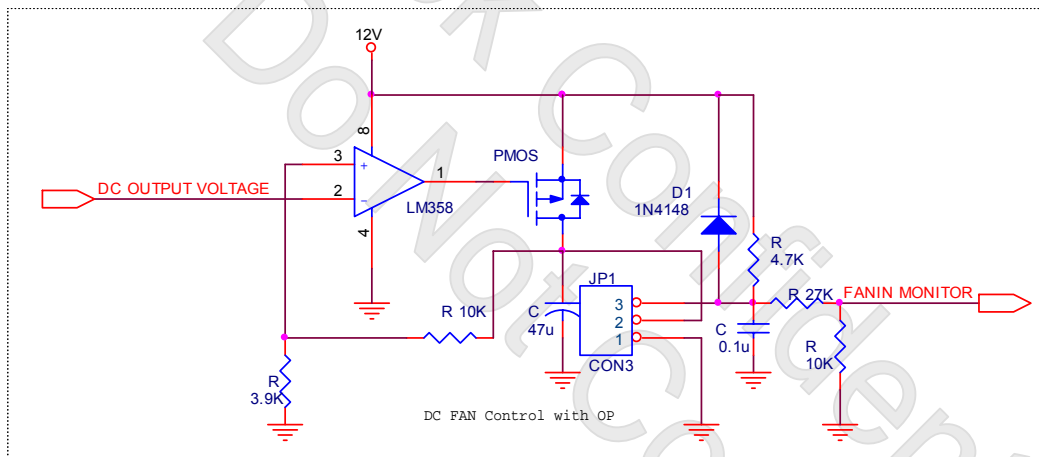
PWM duty Fan Control

The duty cycle of PWM can be programmed by a 8-bit register which are defined in the CR75h and CR85h. The default duty cycle is set to 100%, that is, the default 8-bit registers is set to FFh. The expression of duty can be represented as follows.

$$Duty\_cycle(\%) = \frac{Programmed\ 8 \text{-} bit\ Register\ Value}{255} \times 100\%$$
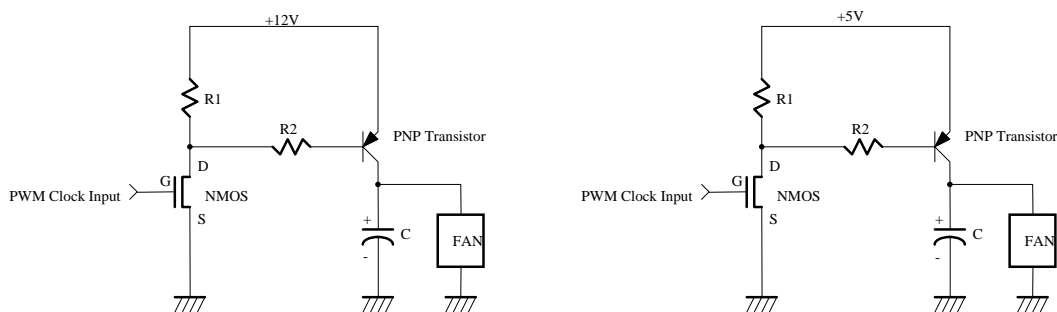
Fan speed control mechanism

July, 2007
0.27P

There are 3 modes to control fan speed and they are manual, fan speed mode and temperature mode. For manual mode, it generally acts as software fan speed control. As for speed mode and temperature mode, they are more intelligent fan speed control and described as below:

1. Speed mode

Speed mode is an intelligent method according to expected fan speed pre-setting by BIOS. In the beginning, fan speed will operate at full speed and the F75387 will get the full speed count value. After that, the fan speed will automatically rotate according to the expected fan speed setting by BIOS. The register CR74h and CR75h are used for this mode.

2. Temperature mode

At this mode, the F75387 provides automatic fan speed control related to temperature variation of CPU/GPU or the system. The F75387 can provide four temperature boundaries and five intervals, and each interval has its related fan speed count. All these values should be set by BIOS first. Take figure 6-2 as example. When temperature boundaries are set as 45, 55, 65, and 75°C and there are five intervals (each interval is 10°C). The related desired fan speed counts for each interval are 0500h, 0400h, 0300h, 0200h, 0100h. When the temperature is within 55~65°C, the fan speed count 300h will be load into FAN EXPECT COUNTregisters(CR74h~CR75h, CR84h~CR85h). Then, the F75387 will adjust PWMOUT duty-cycle to meet the expected value. It can be said that the fan will be turned on with a specific speed set by BIOS and automatically controlled with the temperature variation. The F75387 will take charge of all the fan speed control and need no software support.
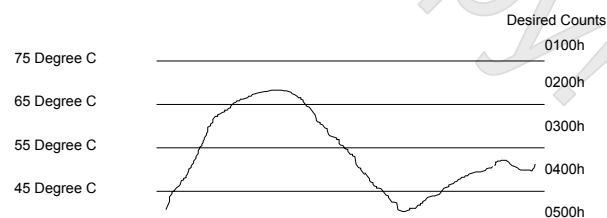
Figure 6-2

PWMOUT Duty-cycle operating process

In both "SPEED" and "TEMPERATURE" modes, the F75387 adjust PWMOUT duty-cycle according to current fan count and expected fan count. It will operate as follows:

(1). When expected count is FFFFh, PWMOUT duty-cycle will be set to 00h to turn off fan.
(2). When expected count is 0000h, PWMOUT duty-cycle will be set to FFh to turn on fan with full speed.
(3). If both (1) and (2) are not true,

(a). When PWMOUT duty-cycle decrease to MIN_DUTY(≠ 00h), obviously the duty-cycle will decrease to 00h next, the F75387 will keep duty-cycle at 00h for 1.6 seconds. After that, the F75387 starts to compare current fan count and expected count in order to increase or decrease its duty-cycle. This ensures that if there is any glitch during the period, the F75387 will ignore it.

Start Duty

Stop Duty
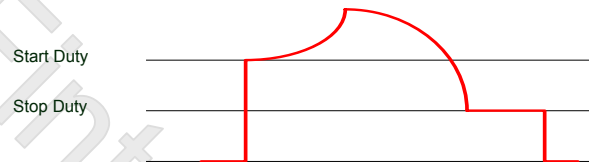
6.12. FAN_Fault#

Fan_Fault# will be asserted when the fan speed doesn't meet the expected fan speed within a programmable period (default is 11 seconds) or when fan stops with respect to PWM duty-cycle which should be able to turn on the fan. There are two conditions may cause the FAN_FAULT# event.

(1). When PWM_Duty reaches FFh, the fan speed count can't reach the fan expected count in time. (Figure 6-3)

11 sec(default)

Current Fan Count

Expected Fan Count

100%

Duty-cycle

Fan_Fault#
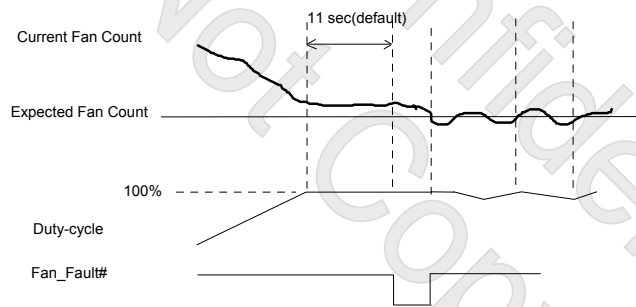
Figure 6-3

(2). After the period of detecting fan full speed, when PWM_Duty > Min. Duty, and current fan count is monitored FFFFh.

6.13. SMI#

Temperature

SMI# interrupt for temperature is shown as figure 6-4. There are two types of temperature SMI# interrupt.

1. Temperature exceeding high limit or going below hystersis will cause an interrupt if the previous interrupt has been reset by writing "1" all the interrupt Status Register.

*Interrupt Reset when Interrupt Status Registers are written 1
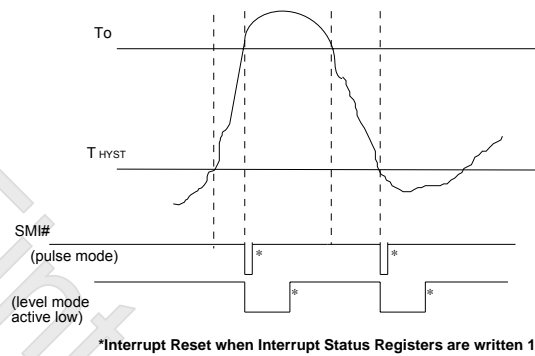
Figure 6-4

2. Temperature is not in the target range for the queue time:

*Interrupt Reset when Interrupt Status Registers are written
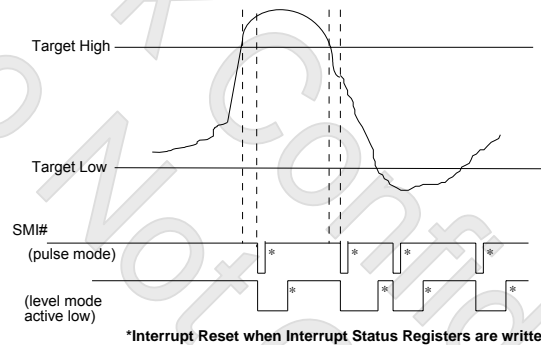
Voltage

SMI# interrupt for voltage is shown as figure below (Figure 6-5). Voltage exceeding or going below high limit will cause an interrupt if the previous interrupt has been reset by writing "1" all the interrupt Status Register. Voltage exceeding or going below low limit will result in the same condition as voltage exceeding or going below high limit.

Fan

SMI# can be used to replace the FAN_FAULT# function .

*Interrupt Reset when Interrupt Status Registers are written 1
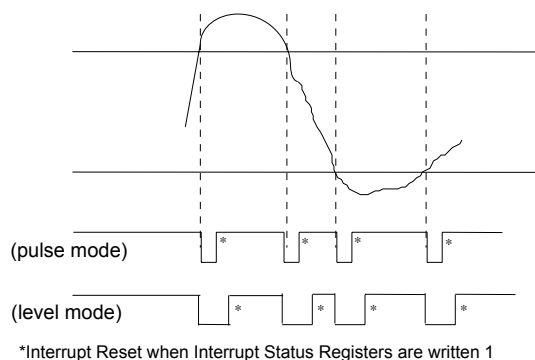
Figure 6-5 :Voltage SMI# Mode

16

6.14. VOLT_FAULT# (Voltage Fault Signal)

When voltage leaps from the security range setting by BIOS, the warning signal VOLT_FAULT# will be activated. Shown in figure 6-6
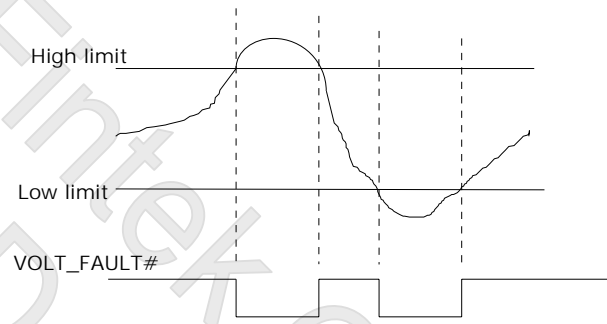
Figure 6-6

7. PCB Layout Guide

PCB can be electrically noisy environments, and the F75387 is measuring very small voltage from the remote sensor, so care must be taken to minimize noise which is occurred at the sensor inputs. The following guideline should be taken to reduce the measurement error of the temperature sensors:

1. Place the F75387 as close as practical to the remote sensing diode. In noisy environments, such as a computer main-board, the distance can be 4 to 8 inches. (typ). This length can be increased if the worst noise sources are avoided. Noise sources generally include clock generators, switching power plane, CRTs, memory buses and PCI/ISA bus etc.

2. Route the D+ and Pin9 GND(D-) tracks close together, in parallel, with grounded guard tracks on each side. Provide a ground plane under the tracks if possible. Do not route D+ & Pin9 GND(D-) lines next to the deflection coil of the CRT. And also don't route the trace across fast digital signals which can easily induce bigger error.
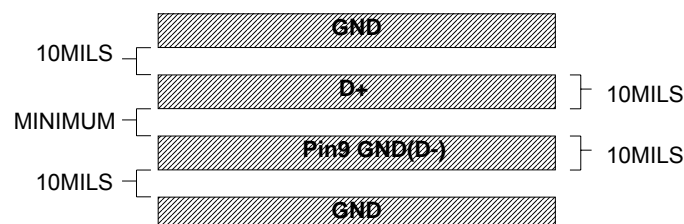
3. Use wide tracks to minimize inductance and reduce noise pickup. 10 mil track minimum width and spacing is recommended.

4. Try to minimize the number of copper/solder joints, which can cause thermocouple effects. Where copper/solder joints are used, make sure that they are in both the D+ and Pin9 GND(D-) path and at the same temperature. Thermocouple effects should not be a major problem as 1 corresponds to about 200µV. It means that a copper-solder thermocouple exhibits 3µV/ , and takes about 200µV of the voltage error at D+ & Pin9 GND(D-) to cause a 1 measurement error. Adding a few thermocouples causes a negligible error.

5. Place a 0.1µF bypass capacitor close to the V_{DD} pin. In very noisy environments, place an external 2200pF input filter capacitors across D+, Pin9 GND(D-) close to the F75387.

6. If the distance to the remote sensor is more than 8 inches, the use of twisted pair cable is recommended. It will work up to around 6 to 12 feet.

7. Because the measurement technique uses switched current sources, excessive cable and/or filter capacitance will affect the measurement accuracy. When using long cables, the filter capacitor may be reduced or removed. Cable resistance can also induce errors. 1 Ω series resistance introduces about 0.5 error.

8. Register Description

8.1. Configuration Register — Index 00h

Power on default <7:0> = 0000_0101 b

Bit	Name	Attribute	Description
7	INIT	R/W	Set one restores power on default value to all registers except the Serial Bus Address register. This bit clears itself since the power on default is zero.
6	LOW_POWR	R/W	Set this bit to 1, then each monitor cycle become 0.2 Sec
5	Reserved	RO	Read back will be 0
4	CLK24M_SEL	R/W	When external clock is used, set this bit to 1 indicates the external clock is 24MHz.
3	POWR_DOWN	R/W	Set the bit to 1 will power down internal circuit..
2	EN_SMI	R/W	0: disable SMI function. 1: enable SMI function. (default)

1	EN_ARA_MODE	R/W	This register is reset by ARA command.
			Enable SMBAlert.
0	START	R/W	Set one to enable startup of monitoring operations; a zero puts the part in standby mode.

8.2. Configuration Register — Index 01h

Power on default <7:0> = 0x00_1100 b

Bit	Name	Attribute	Description
7	Reserved	-	Return 0 when read
6	FAN_FULL_DUTY	R/W	0: The PWM duty will be 60% during the keep full time. 1: The PWM duty will be 100% during the keep full time. The mode is trappable. If the pull-up resistor of pin3 is 10k or none, the default is 0 (60%). If the pull-up resistor of pin3 is 2.2k or 200k, the default is 1(100%).
5	EN_V_FAULT_PIN2	R/W	0: The PIN2 will act as GPIO0/FANIN2 which is controlled by PIN2_MODE register.(default) 1: The PIN2 will act as VOLT_FAULT#
4	EN_F_FAULT_PIN4	R/W	0: The PIN4 will act as GPIO1/PWMOUT2 which is controlled by PIN4_MODE register.(default) 1: The PIN4 will act as FAN_FAULT#.
3	T2_MODE	R/W	0: VT2 is connected to a thermistor 1: VT2 is connected to a BJT(default)
2	T1_MODE	R/W	0: VT1 is connected to a thermistor 1: VT1 is connected to a BJT (default)
1	PIN4_MODE	R/W	Pin 4 mode select. 0: The PIN4 will act as GPIO1.(default) 1: The PIN4 will act as PWMOUT2.
0	PIN2_MODE	R/W	Pin 2 mode select. 0: The PIN2 will act as GPIO0.(default) 1: The PIN2 will act as FANIN2 input.

8.3. Configuration Register — Index 02h

Power on default <7:0> = 0000_0000 b

Bit	Name	Attribute	Description
7-6	PIN5_MODE	R/W	00: pin5 function is GPIO2.(default) 01: pin5 is used as SMI 10: pin5 is used as Fan fault function 11: LED out(1Hz/0.5Hz select by LED_FREQ register)
5	SMI_MODE	R/W	0: SMI will be level mode.(default) 1: SMI will be pulse mode.

4	SMI_LEVEL	R/W	0: SMI is low active.(default) 1: SMI is high active.
3	OVT_MODE	R/W	0: OVT asserts according to the Hysteresis limit 1: OVT asserts according to the target limit.
2	LED_FREQ	R/W	0: The fan fault LED output frequency will be 0.5Hz.(default) 1: The fan fault LED output frequency will be 1Hz.
1	F_FAULT_MODE	R/W	0: The fan fault will be level mode. 1: The fan fault will indicate by LED function (1Hz or 0.5Hz which is controlled by LED_FREQ register).
0	F_FAULT_LEVEL	R/W	0: The fan fault is low active.(default) 1: The fan fault is high active.

8.4. Configuration Register — Index 03h

Power on default <7:0> = 0100_0000 b

Bit	Name	Attribute	Description
7-6	PIN6_MODE	R/W	00: PIN6 will act as GPIO3. 01: PIN6 will act as OVT# 10: PIN6 will act as voltage fault function 11: PIN6 will function as operating clock input function. The external clock should be 24/48MHz. This input clock will be the clock source of the whole chip
5	OVT_LEVEL	R/W	0: The OVT is low active.(default) 1: The OVT is high active.
4-3	OVT_QUEUE	R/W	OVT queue is used to filter the temperature noise, it define the times of the event when OVT# is asserted. 00: 1 times 01: 3 times 10: 5 times 11: 7 times
2	V_FAULT_LEVEL	R/W	0: The voltage fault is low active.(default) 1: The voltage fault is high active.
1-0	V_FAULT_QUEUE	R/W	Voltage fault queue. It is used to filter the voltage noise, the follow define the times of the event when VOLT_FAULT# is asserted. 00: 1 times 01: 3 times 10: 5 times 11: 7 times

8.5. Serial Bus Address Register — Index 04h

Power on default: 5Ah or 5Ch.

Bit	Name	Attribute	Description
7-0	SERIAL_ADDR	R/W	Serial Bus address. Power on default value depends on the status of pin3 (PWMOUT1/ADDR_TRAP) at the moment of power on. If the pin is pull-up by 10K or none, the value is 5Ah; if the pin is pull-up by 2.2k or 200k, the value is 5Ch. To read or write registers of this chip, the serial address must match this value. This register can be written by a sequence value to this register: A9h, C3h, XXh, in which XXh will be the value being written to this register; this is to protect the register from being written by accident. Write XXh to this register will return to default value.

8.6. Value RAM — Index 10h- 2Fh

Address 10-3F	Attribute	Default Value	Description
10h	RO		VCC reading. The unit of reading is 8mV.
11h	RO		V1 reading. The unit of reading is 8mV.
12h	RO		V2 reading. The unit of reading is 8mV.
13h	RO		V3 reading. The unit of reading is 8mV.
14h	RO		Temperature 1 reading (MSB). The unit of reading is 1°C.At the moment of reading this register, the LSB will be latched. This will prevent from data updating when reading. To read the temperature value correctly, read MSB first and followed read the LSB.
15h	RO		Temperature 2 reading (MSB). The unit of reading is 1°C. At the moment of reading this register, the LSB will be latched. This will prevent from data updating when reading. To read the temperature value correctly, read MSB first and followed read the LSB.
16h	RO		FAN1 count reading (MSB). At the moment of reading this register, the LSB will be latched. This will prevent from data updating when reading. To read the fan count correctly, read MSB first and followed read the LSB.
17h	RO		FAN1 count reading (LSB).
18h	RO		FAN2 count reading (MSB). At the moment of reading this register, the LSB will be latched. This will prevent from data updating when reading. To read the fan count correctly, read MSB first and followed read the LSB.
19h	RO		FAN2 count reading (LSB).
1Ah	RO		Temperature 1 reading (LSB). The unit is 1/256 $^\circ$C
1Bh	RO		Temperature 2 reading (LSB). The unit is 1/256 $^\circ$C
1Ch	RO		Local Temperature reading(MSB). The unit of reading is 1°C. The unit of reading is 1°C.At the moment of reading this register, the LSB will be latched. This will prevent from ADC update the data when reading. To read the temperature value correctly, read MSB first and followed read the LSB.

1Dh	RO		Local Temperature reading (LSB). The unit is 1/256 $^\circ$C
1Eh	RO		The V1 – VCC value. The MSB and LSB are in the same index. To read the whole register, read this register twice continuously.
1Fh	RO		The V3 – V2 value. The MSB and LSB are in the same index. To read the whole register, read this register twice continuously.
20h	R/W	FFh	VCC High Limit. The unit is 8mV. The last two LSBs are fixed to 2'b11.
21h	R/W	00h	VCC Low Limit. The unit is 8mV. The last two LSBs are fixed to 2'b00.
22h	R/W	FFh	V1 High Limit. The unit is 8mV. The last two LSBs are fixed to 2'b11.
23h	R/W	00h	V1 Low Limit. The unit is 8mV. The last two LSBs are fixed to 2'b00.
24h	R/W	FFh	V2 High Limit. The unit is 8mV. The last two LSBs are fixed to 2'b11.
25h	R/W	00h	V2 Low Limit. The unit is 8mV. The last two LSBs are fixed to 2'b00.
26h	R/W	FFh	V3 High Limit. The unit is 8mV. The last two LSBs are fixed to 2'b11.
27h	R/W	00h	V3 Low Limit. The unit is 8mV. The last two LSBs are fixed to 2'b00.
28h	R/W	64h	Temperature sensor 1 High Limit. The unit is 1°C.
29h	R/W	5Fh	Temperature sensor 1 Hysteresis Limit. The unit is 1°C.
2A h	R/W	64h	Temperature sensor 2 High Limit. The unit is 1°C.
2Bh	R/W	5Fh	Temperature sensor 2 Hysteresis Limit. The unit is 1°C.
2Ch	R/W	3Ch	Local Temperature sensor High Limit. The unit is 1°C.
2Dh	R/W	37h	Local Temperature sensor Hysteresis Limit. The unit is 1°C.
2Eh	R/W	00h	External register value.
2Fh	-	-	Reserved

Note: Setting all ones to the high limits for voltages and fans (0111 1111 binary for temperature) means interrupts won't be generated except the case when voltages go below the low limits.

8.7. IRQ/SMI# ENABLE Register 1 — Index 30h

Power-on default [7:0] =0000_0000 b

Bit	Name	Attribute	Description
7	EN_FAN2_SMI	R/W	A one enables the corresponding interrupt status bit for SMI# interrupt
6	EN_FAN1_SMI	R/W	A one enables the corresponding interrupt status bit for SMI# interrupt.
5	EN_VT2_SMI	R/W	A one enables the corresponding interrupt status bit for SMI# interrupt.
4	EN_VT1_SMI	R/W	A one enables the corresponding interrupt status bit for SMI# interrupt.
3	EN_V3_SMI	R/W	A one enables the corresponding interrupt status bit for SMI# interrupt.
2	EN_V2_SMI	R/W	A one enables the corresponding interrupt status bit for SMI# interrupt.
1	EN_V1_SMI	R/W	A one enables the corresponding interrupt status bit for SMI# interrupt.
0	EN_VCC_SMI	R/W	A one enables the corresponding interrupt status bit for SMI# interrupt.

8.8. Interrupt Status Register 1 — Index 31h

Power-on default [7:0] =0000_0000 b

Bit	Name	Attribute	Description
7	FAN2_STS	R/W	This bit is set when the fan2 count exceeds the count limit. Write 1 to clear this bit, write 0 will be ignored.
6	FAN1_STS	R/W	This bit is set when the fan1 count exceeds the count limit. Write 1 to clear this bit, write 0 will be ignored.
5	VT2_STS	R/W	This bit is set when the VT2 temperature sensor is out of the temperature range continuously for the times set by OVT_QUEUE register. Write 1 to clear this bit, write 0 will be ignored.
4	VT1_STS	R/W	This bit is set when the VT1 temperature sensor is out of the temperature range continuously for the times set by OVT_QUEUE register. Write 1 to clear this bit, write 0 will be ignored.
3	V3_STS	R/W	This bit is set when the VIN3 is over the high limit or under the low limit. Write 1 to clear this bit, write 0 will be ignored.
2	V2_STS	R/W	This bit is set when the VIN2 is over the high limit or under the low limit. Write 1 to clear this bit, write 0 will be ignored.
1	V1_STS	R/W	This bit is set when the VIN1 is over the high limit or under the low limit. Write 1 to clear this bit, write 0 will be ignored.
0	VCC_STS	R/W	This bit is set when the VCC is over the high limit or under the low limit. Write 1 to clear this bit, write 0 will be ignored.

8.9. Real Time Status Register 1 — Index 32h

Power-on default [7:0] =0000_0000 b

Bit	Name	Attribute	Description
7	FAN2_EXC	R/W	A one indicates fan2 count limit has been exceeded. A zero indicates fan2 count is in the safe region.
6	FAN1_EXC	R/W	A one indicates fan1 count limit has been exceeded. A zero indicates fan1 count is in the safe region.
5	VT2_EXC	R/W	A one indicates VT2 temperature sensor is out of the range set by the register 6Ch and 6Dh continuously for the times set by the OVT_QUEUE register.
4	VT1_EXC	R/W	A one indicates VT1 temperature sensor is out of the range set by the register 6Ah and 6Bh continuously for the times set by the OVT_QUEUE register.

3	V3_EXC	R/W	A one indicates VIN3 exceeds the high or low limit. A zero indicates VIN3 is in the safe region.
2	V2_EXC	R/W	A one indicates VIN2 exceeds the high or low limit. A zero indicates VIN2 is in the safe region.
1	V1_EXC	R/W	A one indicates VIN1 exceeds the high or low limit. A zero indicates VIN1 is in the safe region.
0	VCC_EXC	R/W	A one indicates VCC exceeds the high or low limit. A zero indicates VCC is in the safe region.

8.10. IRQ/SMI# ENABLE Register 2 — Index 33h

Power-on default [7:0] =0000_0000 b

Bit	Name	Attribute	Description
7	Reserved	RO	Return one when read.
6	EN_OVT2_SMI	R/W	Enable temperature 2 OVT fault trigger SMI resister.
5	EN_OVT1_SMI	R/W	Enable temperature 1 OVT fault trigger SMI resister.
4	EN_OVT0_SMI	R/W	Enable temperature 0 (local temperature) OVT fault trigger SMI resister.
3	EN_V3_FAULT_SMI	R/W	Enable Voltage 3 fault trigger SMI resister.
2	EN_V2_FAULT_SMI	R/W	Enable Voltage 2 fault trigger SMI resister.
1	EN_V1_FAULT_SMI	R/W	Enable Voltage 1 fault trigger SMI resister.
0	EN_VCC_FAULT_SMI	R/W	Enable Voltage VCC fault trigger SMI resister.

8.11. Interrupt Status Register 2 — Index 34h

Power-on default [7:0] =0000_0000 b

Bit	Name	Attribute	Description
7	Reserved	RO	Return 0 when read.
6	OVT2_SMI_STS	R/W	A one indicates VT2 temperature sensor has exceeded high limit or below the hysteresis limit. Write 1 to clear this bit, write 0 will be ignored.
5	OVT1_SMI_STS	R/W	A one indicates VT1 temperature sensor has exceeded high limit or below the hysteresis limit. Write 1 to clear this bit, write 0 will be ignored.
4	OVT0_SMI_STS	R/W	A one indicates VT0 temperature sensor (local temperature) has exceeded the high limit or below the hysteresis limit. Write 1 to clear this bit, write 0 will be ignored.
3	V3_FAULT_SMI_STS	R/W	A one indicates VIN3 has exceeded the high or low limit continuously for the times set by V_FAULT_QUEUE register. Write 1 to clear this bit, write 0 will be ignored.

2	V2_FAULT_SMI_STS	R/W	A one indicates VIN2 has exceeded the high or low limit continuously for the times set by V_FAULT_QUEUE register. Write 1 to clear this bit, write 0 will be ignored.
1	V1_FAULT_SMI_STS	R/W	A one indicates VIN1 has exceeded the high or low limit continuously for the times set by V_FAULT_QUEUE register. Write 1 to clear this bit, write 0 will be ignored.
0	VCC_FAULT_SMI_STS	R/W	A one indicates VCC has exceeded the high or low limit continuously for the times set by V_FAULT_QUEUE register. Write 1 to clear this bit, write 0 will be ignored.

8.12. VOLT_FAULT/OVT real time status Register — Index 35h

Power-on default [7:0] =0000_0000 b

Bit	Name	Attribute	Description
7	Reserved	R	Return one when read.
6	T2_OVT	R	Set when the VT2 exceeds the high limit. Clear when the VT2 is below the hysteresis limit.
5	T1_OVT	R	Set when the VT2 exceeds the high limit. Clear when the VT2 is below the hysteresis limit.
4	T0_OVT	R	Set when the VT2 exceeds the high limit. Clear when the VT2 is below the hysteresis limit.
3	V3_FAULT	R	Set 1 when the VIN3 exceeds the high or low limit continuously for the times set by the V_FAULT_QUEUE, set 0 when the VIN3 resides in the safe region continuously for the times set by the V_FAULT_QUEUE.
2	V2_FAULT	R	Set 1 when the VIN2 exceeds the high or low limit continuously for the times set by the V_FAULT_QUEUE, set 0 when the VIN2 resides in the safe region continuously for the times set by the V_FAULT_QUEUE.
1	V1_FAULT	R	Set 1 when the VIN1 exceeds the high or low limit continuously for the times set by the V_FAULT_QUEUE, set 0 when the VIN1 resides in the safe region continuously for the times set by the V_FAULT_QUEUE.
0	VCC_FAULT	R	Set 1 when the VCC exceeds the high or low limit continuously for the times set by the V_FAULT_QUEUE, set 0 when the VCC resides in the safe region continuously for the times set by the V_FAULT_QUEUE.

8.13. REAL TIME Fault Status Register 1 — Index 36h

Power-on default [7:0] =0011_0000 b

Bit	Name	Attribute	Description
7	EN_FAN2_FAULT	R/W	Enable fan fault mechanism of FAN2.
6	EN_FAN1_FAULT	R/W	Enable fan fault mechanism of FAN1.
5	EN_T2_OVT	R/W	Enable over temperature mechanism of VT2.
4	EN_T1_OVT	R/W	Enable over temperature mechanism of VT1.
3	EN_V3_FAULT	R/W	Enable voltage fault mechanism of VIN3.
2	EN_V2_FAULT	R/W	Enable voltage fault mechanism of VIN2.
1	EN_V1_FAULT	R/W	Enable voltage fault mechanism of VIN1.
0	EN_VCC_FAULT	R/W	Enable voltage fault mechanism of VCC.

8.14. CHIPID(1) Register – Index 5Ah

Power-on default [7:0] =0000_0100 b

Bit	Name	Attribute	Description
7-0	CHIPID	RO	Chip ID, High byte (8'h04).

8.15. CHIPID(2) Register – Index 5Bh

Power-on default [7:0] =0001_0000 b

Bit	Name	Attribute	Description
7-0	CHIPID	RO	Chip ID, Low byte (8'h10).

8.16. VENDOR ID(1) Register – Index 5Dh

Power-on default [7:0] =0001_1001 b

Bit	Name	Attribute	Description
7-0	VENDOR1	RO	Vendor ID, high byte (8'h19)

8.17. VENDOR ID(2) Register – Index 5Eh

Power-on default [7:0] =0011_0100 b

Bit	Name	Attribute	Description
7-0	VENDOR2	RO	Vendor ID, low byte (8'h34)

8.18. SMART FAN Lookup Table Hysteresis and FAN mode Register -- Index 60h

Power-on default [7:0] =x1x0_x1x0 b

Bit	Name	Attribute	Description
7	PWM2_PAD_TYPE	R/W	This register control the pad type of pin4 when it act as PWMOUT2: 0: open drain. 1: push pull. This register is trappable. Power on default value depends on the status of pin3 (PWMOUT1/ADDR_TRAP) at the moment of power on. If the pin is pull-up by 200K or none, the value is 1; if the pin is pull-up by 2.2k or 10k, the value is 0.
6	FAN2_DUTY_MODE	R/W	0: indicates the fan control will follow the expected RPM. 1: indicates the fan control will follow the expected PWM duty.
5	FAN2_DAC_MODE	R/W	0: indicates the fan control is a PWM fan. 1: indicates the fan control is a DAC fan. Power on default value depends on the status of pin3 (PWMOUT1/ADDR_TRAP) at the moment of power on. If the pin is pull-up by 200K or none, the mode is DAC mode; if the pin is pull-up by 10k or 2.2k, the mode is PWM mode.
4	FAN2_MANU_MODE	R/W	0: indicates the fan control is in auto mode (auto generates expected fan speed according to the monitor value of VT2 temperature sensor). 1: indicates the fan control is in manual mode (program expected fan speed to CR84, CR85).
3	PWM1_PAD_TYPE	R/W	This register control the pad type of PWMOUT1: 0: open drain. 1: push pull. This register is trappable. Power on default value depends on the status of pin3 (PWMOUT1/ADDR_TRAP) at the moment of power on. If the pin is pull-up by 200K or none, the value is 1; if the pin is pull-up by 2.2k or 10k, the value is 0.
2	FAN1_DUTY_MODE	R/W	0: indicates the fan control will follow the expected RPM. 1: indicates the fan control will follow the expected PWM duty.
1	FAN1_DAC_MODE	R/W	0: indicates the fan control is a PWM fan. 1: indicates the fan control is a DAC fan. Power on default value depends on the status of pin3 (PWMOUT1/ADDR_TRAP) at the moment of power on. If the pin is pull-up by 200K or none, the mode is DAC mode; if the pin is pull-up by 10k or 2.2k, the mode is PWM mode.
0	FAN1_MANU_MODE	R/W	0: indicates the fan control is in auto mode (auto generate expected fan speed according to the monitor value of VT1 temperature sensor). 1: indicates the fan control is in manual mode (program expected fan speed to CR74, CR75).

8.19. Fan Fault Time Register -- Index 61h

Power-on default [7:0] =0000_1010b

Bit	Name	Attribute	Description
7	FAN2_DEB	R/W	0: FAN2 de-bounce circuit is 1.28ms 1: FAN2 de-bounce circuit is 640us.
6	FAN1_DEB	R/W	0: FAN1 de-bounce circuit is 1.28ms 1: FAN1 de-bounce circuit is 640us.
5-0	F_FAULT_TIME	R/W	This register determines the time of fan fault. The condition to cause fan fault event is: When PWM_Duty reaches FFh, if the fan speed count can't reach the fan expect count in time. The unit of this register is 1 second. The default value is 11 seconds. (Set to 0 , means 1 seconds. ; Set to 1, means 2 seconds. Set to 2, means 3 seconds. ….) Another condition to cause fan fault event is fan stop and the PWM duty is greater than the minimum duty programmed by the register 69h.

8.20. Boundary Hysteresis Register -- Index 62h

Power-on default [7:0] =1001_0100 b

Bit	Name	Attribute	Description
7-6	FAN2_T_SEL	R/W	This is the temperature source which FAN2 according to. 00: local temperature. 01: external temperature 1. 10: external temperature 2. (default) 11: disable.
5-4	FAN1_T_SEL	R/W	This is the temperature source which FAN1 according to. 00: local temperature. 01: external temperature 1. (default) 10: external temperature 2. 11: disable.
3-0	HYS	R/W	Boundary hysteresis. (0~15 degree C) Segment will change when the temperature is over the boundary temperature and below the (boundary – hysteresis).

8.21. Fan Full Time Register -- Index 63h

Power-on default [7:0] =0000_0111 b

Bit	Name	Attribute	Description
7-6	FAN2_TYPE	R/W	00, 01: use Fintek application circuit to control fan speed by fan's power terminal . 10: use application circuit to control fan speed by fan's GND terminal. 11: use Intel 4-wire fans.
5-4	FAN1_TYPE	R/W	00, 01: use Fintek application circuit to control fan speed by fan's power terminal 10: use application circuit to control fan speed by fan's GND terminal 11: use Intel 4-wire fans.
3-0	FAN_FULL_TIME	R/W	The keep full time when fan startup. The fan will keep full when power on until the fan is detected enabled and count to the time programmed. (0, means 1second. ; 1, means 2 seconds. ; 2. means 3 seconds …)

8.22. Filter Fast Update Value Register -- Index 67h

Power-on default [7:0] =0000_1111 b

Bit	Name	Attribute	Description
7-4	Reserved	-	Return 0 when read.
3-2	UPDATE_QUEUE2	R/W	The queue time for second filter to quickly update values. 00: disable quick update function. 01: 16 times.(default) 10: 32 times. 11: 48 times.
1-0	UPDATE_QUEUE1	R/W	The queue time for second filter to quickly update values. 00: disable quick update function. 01: 16 times.(default) 10: 32 times. 11: 48 times.

8.23. PWMOUT1 START UP DUTY-CYCLE — Index 69h

Power-on default [7:0] =0101_0101 b

Bit	Name	Attribute	Description
7-4	FAN2_MIN_DUTY	R/W	When fan starts, the PWMOUT2 will increase duty-cycle from 0 to this (value x 8) directly. And if fan speed is down, the PWMOUT2 will decrease duty-cycle to 0 when the PWM duty cycle is less than this (value x 4).
3-0	FAN1_MIN_DUTY	R/W	When fan starts, the PWMOUT1 will increase duty-cycle from 0 to this (value

| | | | x 8 directly. And if fan speed is down, the PWMOUT1 will decrease duty-cycle to 0 when the PWM duty cycle is less than this (value x 4). |

8.24. T1 OVT TARGET TEMPERATURE HIGH— Index 6Ah

Power on default: 64h

Bit	Name	Attribute	Description
7-0	TARGET_HI1	R/W	When temperature 1 exceeds this value, the OVT will be asserted.

8.25. T1 OVT TARGET TEMPERATURE LOW — Index 6Bh

Power on default: 46h

Bit	Name	Attribute	Description
7-0	TARGET_LOW1	R/W	When temperature 1 is lower than this value, the OVT will be asserted.

8.26. T2 OVT TARGET TEMPERATURE HIGH— Index 6Ch

Power on default: 64h

Bit	Name	Attribute	Description
7-0	TARGET_HI2	R/W	When temperature 2 exceeds this value, the OVT will be asserted.

8.27. T2 OVT TARGET TEMPERATURE LOW — Index 6Dh

Power on default: 46h

Bit	Name	Attribute	Description
7-0	TARGET_LOW2	R/W	When temperature 2 is lower than this value, the OVT will be asserted.

8.28. FAN1 Full Speed Count Register 0 — Index 70h

Power on default: 00h

Bit	Name	Attribute	Description
7-4	Reserved	RO	Always return 0.
3-0	FAN1_FULL (MSB)	R/W	This register indicates the MSB of the FAN1 full speed count. This register can be auto updated by hardware or program by user. If user programs this register before hardware, then the hardware will not update this register again.

8.29. FAN1 full speed Count Register 1— Index71h

Power on default: F0h

Bit	Name	Attribute	Description

7-0	FAN1_FULL (LSB)	R/W	This register indicates the LSB of the FAN1 full speed count. This register can be auto updated by hardware or program by user. If user programs this register before hardware, then the hardware will not update this register again.

8.30. FAN1 expect count Register-- Index 74h

Power on default [7:0] = 00h

Bit	Name	Attribute	Description
7-4	Reserved	RO	Return 0 when read.
7-0	FAN1_EXPECT (MSB)	R/W	Expected fan speed count value or expected PWM duty , in auto fan mode this register is auto updated by hardware and read only.

8.31. FAN1 expect count Register-- Index 75h

Power on default [7:0] = 01h

Bit	Name	Attribute	Description
7-0	FAN1_EXPECT (LSB)	R/W	Expected fan speed count value or expected PWM duty, in auto fan mode this register is auto updated by hardware and read only

8.32. FAN1 PWM_duty -- Index 76h

Power on default: FFh

Bit	Name	Attribute	Description
7-0	PWM_DUTY1	R	This register reflects current PWMOUT1 duty-cycle.

8.33. FAN2 Full Speed Count Register 0 — Index 80h

Power on default: 00h

Bit	Name	Attribute	Description
7-4	Reserved	-	Return 0 when read.
3-0	FAN2_FULL (MSB)	R/W	This register indicates the LSB of the FAN1 full speed count. This register can be auto update by hardware or program by user. If user programming this register before hardware, then the hardware will not update this register again.

8.34. FAN2 full speed Count Register 1— Index81h

Power on default: F0h

Bit	Name	Attribute	Description

7-0	FAN2_FULL (LSB)	R/W	This register indicates the LSB of the FAN1 full speed count. This register can be auto update by hardware or program by user. If user programming this register before hardware, then the hardware will not update this register again.

8.35. FAN2 expect count Register-- Index 84h

Power on default [7:0] = 00h

Bit	Name	Attribute	Description
7-4	Reserved	-	Return 0 when read.
7-0	FAN2_EXPECT (MSB)	R/W	Expect fan speed count value or expect PWM duty , in auto fan mode this register is auto updated by hardware and read only.

8.36. FAN2 expect count Register-- Index 85h

Power on default [7:0] = 01h

Bit	Name	Attribute	Description
7-0	FAN2_EXPECT (LSB)	R/W	Expect fan speed count value or expect PWM duty , in auto fan mode this register is auto updated by hardware and read only.

8.37. FAN2 PWM_duty -- Index 86h

Power on default: FFh

Bit	Name	Attribute	Description
7-0	PWM_DUTY2	R/W	This register reflects current PWMOUT2 duty-cycle.

8.38. GPIOx Output Control Register – Index 90h

Power-on default [7:0] =0000_0000b

Bit	Name	Attribute	Description
7-4	Reserved	RO	Return 0 when read.
3	GPIO3_OCTRL	R/W	GPIO3 output control. Set to 1 for output function. Set to 0 for input function (default).
2	GPIO2_OCTRL	R/W	GPIO2 output control. Set to 1 for output function. Set to 0 for input function (default).
1	GPIO1_OCTRL	R/W	GPIO1 output control. Set to 1 for output function. Set to 0 for input function (default).
0	GPIO0_OCTRL	R/W	GPIO0 output control. Set to 1 for output function. Set to 0 for input function (default).

8.39. GPIOx Output Data Register – Index 91h

Power-on default [7:0] =0000_0000b

Bit	Name	Attribute	Description
7-4	Reserved	RO	Return 0 when read.
3	GPIO3_ODATA	R/W	GPIO3 output data.
2	GPIO2_ODATA	R/W	GPIO2 output data.
1	GPIO1_ODATA	R/W	GPIO1 output data.
0	GPIO0_ODATA	R/W	GPIO0 output data.

8.40. GPIO1x Input Status Register – Index 92h

Power-on default [7:0] = N.A.

Bit	Name	Attribute	Description
7-4	Reserved	RO	Return 0 when read.
3	GPIO3_PSTS	RO	Read the pin status of pin6.
2	GPIO2_PSTS	RO	Read the pin status of pin5.
1	GPIO1_PSTS	RO	Read the pin status of pin4.
0	GPIO0_PSTS	RO	Read the pin status of pin2.

INDEX A0 -- AD registers – FAN1 CONTROL v.s. TEMPERATURE 1

8.41. VT1 BOUNDARY 1 TEMPERATURE – Index A0h

Power-on default [7:0] =46h

Bit	Name	Attribute	Description
7	Reserved	RO	Return 0 when read.
6-0	BOUND1TMP1	R/W	The 1st BOUNDARY temperature for VT1 in temperature mode. When VT1 temperature **exceeds** this boundary, FAN1 segment **1** speed count register (index A4h x 16 or index A4h depending on the FAN1_MODE[2] register) will be loaded into FAN1 expected count registers (index 74h, 75h). When VT1 temperature is **below** this boundary – hysteresis, FAN1 segment **2** speed count register (index A5h x 16 or index A5h depending on the FAN1_MODE[2] register) will be loaded into FAN1 expected count registers(index 74h,75h).

8.42. VT1 BOUNDARY 2 TEMPERATURE – Index A1h

Power-on default [7:0] =3Ch

Bit	Name	Attribute	Description
7	Reserved	-	Return 0 when read.
6-0	BOUND2TMP1	R/W	The 2nd BOUNDARY temperature for VT1 in temperature mode. When VT1 temperature **exceeds** this boundary, FAN1 segment **2** speed count register (index A5h x 16 or index A6h depending on the FAN1_MODE[2] register) will be loaded into FAN1 expected count registers (index 74h,75h). When VT1 temperature is **below** this boundary - hysteresis, FAN1 segment **3** speed count registers (index A6h x16 or index A7h depending on the FAN1_MODE[2] register) will be loaded into FAN1 expected count registers(index 74h,75h).

8.43. VT1 BOUNDARY 3 TEMPERATURE – Index A2h

Power-on default [7:0] =32h

Bit	Name	Attribute	Description
7	Reserved	-	Return 0 when read.
6-0	BOUND3TMP1	R/W	The 3rd BOUNDARY temperature for VT1 in temperature mode. When VT1 temperature **exceeds** this boundary, FAN1 segment **3** speed count register (index A6h x 16 or index A6h depending on the FAN1_MODE[2] register) will be loaded into FAN1 expected count registers(index 74h,75h). When VT1 temperature is **below** this boundary, FAN1 segment **4** speed count register (index A7h x 16 or index A7h depending on the FAN1_MODE[2] register) will be loaded into FAN1 expect count registers(index 74h,75h).

8.44. VT1 BOUNDARY 4 TEMPERATURE – Index A3h

Power-on default [7:0] =28h

Bit	Name	Attribute	Description
7	Reserved	-	Return 0 when read.
6-0	BOUND4TMP1	R/W	The 4th BOUNDARY temperature for VT1 in temperature mode. When VT1 temperature **exceeds** this boundary, FAN1 segment **4** speed count register (index A8h x 16 or A8h depending on the FAN1_MODE[2]

register) will be loaded into FAN1 expected count registers (index 74h,75h). When VT1 temperature is **below** this boundary, FAN1 segment **5** speed count registers(index A9h x 16 or A9h depending on the FAN1_MODE[2] register) will be loaded into FAN1 expected count registers (index 74h,75h).

8.45. FAN1 SEGMENT 1 SPEED COUNT – Index A4h

Power-on default [7:0] =FFh

Bit	Name	Attribute	Description
7-0	SEC1SPEED1	R/W	The meaning of this register is depending on the FAN1_MODE[2]: 0: the value x 16 is the fan speed count in this range. 1: the value is PWM duty-cycle (In DAC mode, the output voltage is VCC*(SEC1SPEED1)/255) in this range.

8.46. FAN1 SEGMENT 2 SPEED COUNT – Index A5h

Power-on default [7:0] =D9h

Bit	Name	Attribute	Description
7-0	SEC2SPEED1	R/W	The meaning of this register is depending on the FAN1_MODE[2]: 0: the value x 16 is the fan speed count in this range. 1: the value is PWM duty-cycle (In DAC mode, the output voltage is VCC*(SEC2SPEED1)/255) in this range.

8.47. FAN1 SEGMENT 3 SPEED COUNT – Index A6h

Power-on default [7:0] =B2h

Bit	Name	Attribute	Description
7-0	SEC3SPEED1	R/W	The meaning of this register is depending on the FAN1_MODE[2]: 0: the value x 16 is the fan speed count in this range. 1: the value is PWM duty-cycle (In DAC mode, the output voltage is VCC*(SEC3SPEED1)/255) in this range.

8.48. FAN1 SEGMENT 4 SPEED COUNT – Index A7h

Power-on default [7:0] =99h

Bit	Name	Attribute	Description
7-0	SEC4SPEED1	R/W	The meaning of this register is depending on the FAN1_MODE[2]:

0: the value x 16 is the fan speed count in this range.

1: the value is PWM duty-cycle (In DAC mode, the output voltage is

VCC*(SEC4SPEED1)/255) in this range.

8.49. FAN1 SEGMENT 5 SPEED COUNT – Index A8h

Power-on default [7:0] =80h

Bit	Name	R/W	Description
7-0	SEC5SPEED1	R/W	The meaning of this register is depending on the FAN1_MODE[2]: 0: the value x 16 is the fan speed count in this range. 1: the value is PWM duty-cycle (In DAC mode, the output voltage is VCC*(SEC5SPEED1)/255) in this range.

INDEX B0 -- BD registers – FAN2 CONTROL v.s. TEMPERATURE 2

8.50. VT2 BOUNDARY 1 TEMPERATURE – Index B0h

Power-on default [7:0] =46h

Bit	Name	Attribute	Description
7	Reserved	-	Return 0 when read.
6-0	BOUND1TMP2	R/W	The 1st BOUNDARY temperature for VT2 in temperature mode. When VT2 temperature **exceeds** this boundary, FAN2 segment **1** speed count register (index B4h x 16 or index B4h depending on the FAN2_MODE[2] register) will be loaded into FAN2 expected count registers (index 84h, 85h). When VT2 temperature is **below** this boundary – hysteresis, FAN2 segment **2** speed count register (index B5h x 16 or index B5h depending on the FAN2_MODE[2] register) will be loaded into FAN2 expected count register (index 84h, 85h).

8.51. VT2 BOUNDARY 2 TEMPERATURE – Index B1h

Power-on default [7:0] =3Ch

Bit	Name	Attribute	Description
7	Reserved	-	Return 0 when read.
6-0	BOUND2TMP2	R/W	The 2nd BOUNDARY temperature for VT2 in temperature mode. When VT2 temperature **exceeds** this boundary, FAN2 segment **2** speed count register (index B5h x 16 or index B6h depending on the

			FAN1_MODE[2] register) will be loaded into FAN2 expected count registers (index 84h,85h). When VT2 temperature is **below** this boundary - hysteresis, FAN2 segment **3** speed count registers (index A6h x16 or index A7h depending on the FAN2_MODE[2] register) will be loaded into FAN2 expected count registers(index 84h,85h).

8.52. VT2 BOUNDARY 3 TEMPERATURE – Index B2h

Power-on default [7:0] = 32h

Bit	Name	Attribute	Description
7	Reserved	RO	Return 0 when read.
6-0	BOUND3TMP2	R/W	The 3rd BOUNDARY temperature for VT2 in temperature mode. When VT2 temperature **exceeds** this boundary, FAN2 segment **3** speed count register (index B6h x 16 or index B6h depending on the FAN2_MODE[2] register) will be loaded into FAN2 expected count registers(index 84h,85h). When VT2 temperature is **below** this boundary, FAN2 segment **4** speed count register (index B7h x 16 or index B7h depending on the FAN2_MODE[2] register) will be loaded into FAN2 expected count registers(index 74h,75h).

8.53. VT2 BOUNDARY 4 TEMPERATURE – Index B3h

Power-on default [7:0] = 28h

Bit	Name	Attribute	Description
7	Reserved	-	Return 0 when read.
6-0	BOUND4TMP2	R/W	The 4th BOUNDARY temperature for VT2 in temperature mode. When VT2 temperature **exceeds** this boundary, FAN2 segment **4** speed count register (index B8h x 16 or B8h depending on the FAN2_MODE[2] register) will be loaded into FAN2 expected count registers (index 84h,85h). When VT2 temperature is **below** this boundary, FAN2 segment **5** speed count registers(index B9h x 16 or B9h depending on the FAN1_MODE[2] register) will be loaded into FAN2 expected count registers (index 84h,85h).

8.54. FAN2 SEGMENT 1 SPEED COUNT   – Index B4h

Power-on default [7:0] = FFh

Feature Integration Technology Inc.

Bit	Name	Attribute	Description
7-0	SEC1SPEED2	R/W	The meaning of this register is depending on the FAN2_MODE[2]: 0: the value x 16 is the fan speed count in this range. 1: the value is PWM duty-cycle (In DAC mode, the output voltage is VCC*(SEC1SPEED2)/255) in this range.

8.55. FAN2 SEGMENT 2 SPEED COUNT   – Index B5h

Power-on default [7:0] = D9h

Bit	Name	Attribute	Description
7-0	SEC2SPEED2	R/W	The meaning of this register is depending on the FAN2_MODE[2]: 0: the value x 16 is the fan speed count in this range. 1: the value is PWM duty-cycle (In DAC mode, the output voltage is VCC*(SEC2SPEED2)/255) in this range.

8.56. FAN2 SEGMENT 3 SPEED COUNT   – Index B6h

Power-on default [7:0] = B2h

Bit	Name	Attribute	Description
7-0	SEC3SPEED2	R/W	The meaning of this register is depending on the FAN2_MODE[2]: 0: the value x 16 is the fan speed count in this range. 1: the value is PWM duty-cycle (In DAC mode, the output voltage is VCC*(SEC3SPEED2)/255) in this range.

8.57. FAN2 SEGMENT 4 SPEED COUNT   – Index B7h

Power-on default [7:0] = 99h

Bit	Name	Attribute	Description
7-0	SEC4SPEED2	R/W	The meaning of this register is depending on the FAN2_MODE[2]: 0: the value x 16 is the fan speed count in this range. 1: the value is PWM duty-cycle (In DAC mode, the output voltage is VCC*(SEC4SPEED2)/255) in this range.

8.58. FAN2 SEGMENT 5 SPEED COUNT   – Index B8h

Power-on default [7:0] = 80h

Bit	Name	Attribute	Description
7-0	SEC5SPEED2	R/W	The meaning of this register is depending on the FAN2_MODE[2]:

			0: the value x 16 is the fan speed count in this range.
			1: the value is PWM duty-cycle (In DAC mode, the output voltage is VCC*(SEC5SPEED2)/255) in this range.

9. Electrical characteristic

9.1. Absolute Maximum Ratings

PARAMETER	RATING	UNIT
Power Supply Voltage	-0.3 to 3.6	V
Input Voltage	-0.5 to VDD+0.5	V
Operating Temperature	0 to +70	° C
Storage Temperature	-55 to 150	° C

Note: Exposure to conditions beyond those listed under Absolute Maximum Ratings may adversely affect the life and

reliability of the device

9.2. DC Characteristics

(T_A = 0° C to 70° C, VDD = 3.3V $\pm$ 10%, VSS = 0V)

Parameter	Conditions	MIN	TYP	MAX	Unit
Temperature Error, Remote Diode	60 ^{o}C < T_D < 100 ^{o}C, VCC = 3.0V to 3.6V		$\pm$ 1		^{o}C
	0 ^{o}C <T_D < 145 ^{o}C		$\pm$ 1	$\pm$ 3	
Temperature Error, Local Diode	0 ^{o}C < T_A < 100 ^{o}C, VCC = 3.0V to 3.6V		$\pm$ 1	$\pm$ 3	^{o}C
Supply Voltage range		3.0	3.3	3.6	V
Average operating supply current	Fan PWM Mode		2.5	2.8	mA
	Fan DAC Mode		3.5	3.8	
Standby supply current			200	400	uA
Resolution	Voltage		8		mV
	Temperature		0.125		^{o}C
Under-voltage lockout threshold	VDD input, Disables ADC , Rising Edge		2.55		V
Power on reset threshold			2.2	2.4	V
Diode source current	High Level		95		uA
	Low Level		10		uA

(T_A = 0° C to 70° C, VDD = 3.3V $\pm$ 10%, VSS = 0V)

PARAMETER	SYM.	MIN.	TYP.	MAX.	UNIT	CONDITIONS
I/O$_{12ts}$ - TTL level bi-directional pin with source-sink capability of 12 mA and schmitt-trigger level input						
Input Low Threshold Voltage	Vt-	0.5	0.8	1.1	V	VDD = 3.3 V
Input High Threshold Voltage	Vt+	1.6	2.0	2.4	V	VDD = 3.3 V
Output Low Current	IOL	9	12		mA	VOL = 0.4 V
Output High Current	IOH		-12	-9	mA	VOH = 2.4V
Input High Leakage	ILIH			+1	μA	VIN = VDD
Input Low Leakage	ILIL	-1			μA	VIN = 0V
OD$_{12}$ - Open-drain output pin with sink capability of 12 mA						
Output Low Current	IOL	9	12		uA	VOL = 0.4 V
IN$_{ts5V}$ - TTL Schmitt-triggered input pin with 5V tolerance						
Input Low Threshold Voltage	Vt-	0.5	0.8	1.1	V	VDD = 3.3V
Input High Threshold Voltage	Vt+	1.6	2.0	2.4	V	VDD = 3.3V
Input High Leakage	ILIH			+1	μA	VIN = VDD
Input Low Leakage	ILIL	-1			μA	VIN = 0 V
IN$_{ts}$ - TTL level Schmitt-triggered input pin						
Input Low Threshold Voltage	Vt-	0.5	0.8	1.1	V	VDD = 3.3V
Input High Threshold Voltage	Vt+	1.6	2.0	2.4	V	VDD = 3.3V
Input High Leakage	ILIH			+1	μA	VIN = VDD
Input Low Leakage	ILIL	-1			μA	VIN = 0 V

9.3. AC Characteristics

Serial Bus Timing

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
SCL clock period	t$_{SCL}$	10		uS
Start condition hold time	t$_{HD;SDA}$	4.7		uS
Stop condition setup-up time	t$_{SU;STO}$	4.7		uS
DATA to SCL setup time	t$_{SU;DAT}$	120		nS
DATA to SCL hold time	t$_{HD;DAT}$	5		nS
SCL and SDA rise time	t$_R$		1.0	uS
SCL and SDA fall time	t$_F$		300	nS

10. Ordering Information

Part Number	Package Type	Production Flow
F75387SG	16 pin SOP (Green Package)	Commercial, 0°C to +70°C
F75387RG	16 pin SSOP (Green Package)	Commercial, 0°C to +70°C

11. Package Dimensions

SYMBOLS	MIN.	MAX.
A	0.053	0.069
A1	0.004	0.010
A2	–	0.059
b	0.008	0.012
b1	0.008	0.011
c	0.007	0.010
c1	0.007	0.009
D	0.189	0.197
E1	0.150	0.157
E	0.228	0.244
L	0.016	0.050
e	0.025 BASIC	
θ°	0	8

UNIT : INCH

NOTES:
1. JEDEC OUTLINE : MO-137 AB
2. DIMENSIONS "D" DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.MOLD FLASH, PROTRUSIONS AND GATE BURRS SHALL NOT EXCEED .15mm (.006in) PER SIDE.
3. DIMENSIONS "E" DOES NOT INCLUDE INTER-LEAD FLASH, OR PROTRUSIONS. INTER-LEAD FLASH AND PROTRUSIONS SHALL NOT EXCEED .25mm (.010in) PER SIDE.

(16-SSOP Package)

(16-SOP Package)

SYMBOLS	MIN.	MAX.
A	0.053	0.069
A1	0.004	0.010
D	0.386	0.394
E	0.150	0.157
H	0.228	0.244
L	0.016	0.050
θ°	0	8

UNIT : INCH

NOTES:
1. JEDEC OUTLINE : MS-012 AC
2. DIMENSIONS "D" DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.MOLD FLASH, PROTRUSIONS AND GATE BURRS SHALL NOT EXCEED .15mm (.006in) PER SIDE.
3. DIMENSIONS "E" DOES NOT INCLUDE INTER-LEAD FLASH, OR PROTRUSIONS. INTER-LEAD FLASH AND PROTRUSIONS SHALL NOT EXCEED .25mm (.010in) PER SIDE.

Please note that all datasheet and specifications are subject to change without notice. All the trade marks of products and companies mentioned in this datasheet belong to their respective owner

12. F75387 Application Circuit

Function Trapping

PWMOUT1 — R5 — VCC

	R5	PULL_UP Voltage	FAN SPIN-UP SPEED	I2C Address	FAN Type
1	N.C.	N/A	60%	0x5A	DAC
2	200K	VCC3	100%	0x5C	DAC
3	10K	VCC3	60%	0x5C	PWM
4	2.2K	VCC3	100%	0x5A	PWM
5	20K	VCC5	60%	0x5C	PWM
6	2.2K	VCC5	100%	0x5A	PWM

VOLTAGE MONITOR

VIN1 — R1 100K — VDD1 (2.0V)
R2 100K

VIN2 — R3 150K — VDD2 (2.5V)
R4 100K

VIN3 — R11 47K — VDD3 (1.5V)
R12 100K

VIN1,VIN2,VIN3 SIGNALS BEST INPUT LEVEL IS ABOUT 1V

VCC3V

R7 R8 R9
4.7K 4.7K 4.7K

VCC3V

R10 33

U1
F75387

Pin	Signal		Pin	Signal
1	FANIN1		16	VCC
2	GPIO0/FAININ2/VOLT_FAULT#		15	D1+ / T1
3	PWM1/DAC1/ADDR_TRAP		14	D2+ / T2
4	GPIO1/PWM2/DAC2/FAN_FAULT#		13	VREF
5	GPIO2/SMI#/FAN_FAULT#/LED		12	VIN1
6	OVT#/VOLT_FAULT#/GPIO3/CLKIN		11	VIN2
7	SCLK		10	VIN3
8	SDATA		9	GND

FANIN1
FANIN2
PWMOUT1
PWMOUT2
EXT_CLK / SM#
SCLK
SDATA

C1 0.1U   C2 4.7U

Example 1:

TEMPERATURE MONITOR

T1 — THERMDA
C4 3300pF
Pin9(GND)
THERMDC

T2
C5 3300pF
Q1 PNP 3906
Pin9(GND)

Example 2:

TEMPERATURE MONITOR (Thermistor)

VREF — R14 10K 1% — T1 — RT1
10K THERMISTOR

VREF — R15 10K 1% — T2 — RT2
10K THERMISTOR

F75387 Thermal Diode recommended Layout

VCC3V
THERMDA
THERMDC
C8 3300p

1. The THERMDA and THERMDC tracks Must Not pass through/by PWM POWER-MOS, Linear Regulator and Clock generator. Keep as far as possible from POWER MOS.

2. Place an external 3300pF input filter capacitors across THERMDA, THERMDC and close to the F75387. Near the pin GND (Pin# 9) Must Be placed a through hole into the GND Plane before connect to the external 3300pF capacitor.

Title: Feature Integration Technology Inc.
Size B   Document Number: F75387 Demo Circuit   Rev 0.1
Date: Sheet 1 of 2

Fintek

Feature Integration Technology Inc.

FAN1 4_PIN FAN CONTROL

Linear FAN1 CONTROL

PWM FAN1 SPEED CONTROL(3wire FAN)

FAN2 4_PIN FAN CONTROL

Linear FAN2 CONTROL

PWM FAN2 SPEED CONTROL(3wire FAN)

Title
Feature Integration Technology Inc.

Size	Document Number	Rev
B	F75387S Demo Circuit	0.1
Date:	Sheet 2 of 2	

July, 2007
0.27P

13. F75387 Application Circuit & Co-Layout Circuit with F75375

ADDRESS SELECT

For F75387

R12 OPEN   Addr=0x5Ah   60% FAN
R12=200K   Addr=0X5Ch   Full FAN
R12= 10K   Addr=0X5Ch   60% FAN
R12=2.2K   Addr=0X5Ah   Full FAN

For F75375S (R13 OPEN)

R12 OPEN   Addr=0x5Ah
R12=4.7K   Addr=0X5Ch

VOLTAGE MONITOR

VIN1,VIN2,VIN3 SIGNALS BEST INPUT LEVEL IS ABOUT 1V

TEMPERATURE MONITOR (Thermal Diode)

R41 ON : F75375 Thermal Diode Voltage Mode
R41 OFF: F75387 Thermal Diode Current Mode

F75387S Thermal Diode recommended Layout

1. The THERMDA and THERMDC tracks Must Not pass through/by PWM POWER-MOS, Linear Regulator and Clock generator. Keep as far as possible from POWER MOS.

2. Place an external 3300pF input filter capacitors across THERMDA, THERMDC and close to the F75387S. Near the pin GND (Pin# 9) Must Be placed a through hole into the GND Plane before connect to the external 3300pF capacitor.

Example 1:

TEMPERATURE MONITOR

Example 2:

TEMPERATURE MONITOR (Thermistor)

Title	Feature Integration Technology Inc.		
Size B	Document Number F75375S_F75387S Co-Layout Demo Circuit		Rev 0.1
Date:		Sheet 1 of 2	

45

July, 2007
0.27P

FAN1 4_PIN FAN CONTROL

Linear FAN1 CONTROL

PWM FAN1 SPEED CONTROL(3wire FAN)

FAN2 4_PIN FAN CONTROL

Linear FAN2 CONTROL

PWM FAN2 SPEED CONTROL(3wire FAN)

Title		
	Feature Integration Technology Inc.	
Size	Document Number	Rev
B	F75387S Demo Circuit	0.1
Date:	Sheet 2 of 2	

46