



Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of “Quality Parts,Customers Priority,Honest Operation,and Considerate Service”,our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!



Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

Email & Skype: info@chipsmall.com Web: www.chipsmall.com

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China



W83L786R / W83L786G
Nuvoton
H/W Monitoring IC



W83L786R

Data Sheet Revision History

	PAGES	DATES	VERSION	VERSION ON WEB	MAIN CONTENTS
1	P.8	09/29/03	0.6	N/A	Pin 23, 24: from GPIO to VIN1,2
2	P.14, P.18, P.55, P.59	10/22/04	0.7	N/A	Add pin function description, functional description, electrical characteristics and top marking explanation
3	N/A	03/31/06	0.8	N/A	Add Pb-free package type; correct current mode temp. sensor inputs from one set to two sets
4					
5					

Please note that all data and specifications are subject to change without notice. All the trademarks 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. Nuvoton customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Nuvoton for any damages resulting from such improper use or sales.



Table of Contents-

1.	GENERAL DESCRIPTION	1
2.	FEATURES	2
2.1	Monitoring Items	2
2.1.1	Temperature	2
2.1.2	Voltage	2
2.1.3	Fan	2
2.2	Actions Enabling	2
2.3	General	2
2.4	Package	2
3.	KEY SPECIFICATIONS	3
4.	BLOCK DIAGRAM	4
5.	PIN CONFIGURATION	5
6.	PIN DESCRIPTION	6
7.	FUNCTIONAL DESCRIPTION	9
7.1	General Description	9
7.2	Access Interface	9
7.3	The First Serial Bus Access Timing	9
7.4	Analog Inputs	10
7.4.1	Voltage Input can not be over 2.048V	11
7.4.2	Voltage Fault (VOLTAGE_FAULT #)	11
7.5	Temperature Measurement Machine	12
7.5.1	Monitor Temperature from Thermistor	12
7.5.2	Monitor Temperature from Thermal Diode	12
7.5.3	Temperature Fault (TEMP_FAULT #)	13
7.6	FAN Speed Count and FAN Speed Control	13
7.6.1	Fan Speed Count	13
7.6.2	Fan Speed Control	15
7.6.3	SMART FANTM I Control	17
7.6.4	SMART FANTM II Control	18
7.6.5	Fan Fault (FAN_FAULT #)	20
7.7	Fault Signal—INT#	20
7.7.1	Temperature	20
7.7.2	Voltage	22
7.7.3	Fan	22
8.	CONTROL AND STATUS REGISTER	23



8.1	Configuration Register - Index 40h	23
8.2	INT# Status Register 1 - Index 41h.....	23
8.3	INT# Status Register 2 - Index 42h.....	24
8.4	INT# Mask Register 1 - Index 43h.....	24
8.5	INT# Mask Register 2 - Index 44h.....	25
8.6	Watch Dog Timer Register I - Index 45h.....	25
8.7	Watch Dog Timer Register II - Index 46h.....	25
8.8	GPIO/GPO Function Enable Control Register - Index 47h.....	26
8.9	VID0-4/GPIO1-5 I/O Mode Control Register - Index 48h.....	27
8.10	GPIO8-14 I/O Mode Control Register - Index 49h.....	27
8.11	GPO6-7 & VID0-4/GPIO1-5 Output Data Register - Index 4Ah.....	28
8.12	GPIO8-14 Data Register - Index 4Bh.....	29
8.13	Nuvoton Vendor ID (Low Byte) - Index 4Ch.....	29
8.14	Nuvoton Vendor ID (High Byte) - Index 4Dh.....	29
8.15	Chip ID - Index 4Eh.....	29
8.16	VID0-4 Input Data Register - Index 4Fh.....	29
8.17	VID0-4/GPIO1-5 Output Mode Control Register - Index 50h.....	30
8.18	GPIO8-14 Output Mode Control Register - Index 51h.....	31
8.19	INT# Property Select - Index 52h.....	32
8.20	Thermal Sensor 1/2/3 Type Register - Index 53h.....	33
8.21	Fan Divisor Register - Index 54h.....	33
8.22	Reserved - Index 55h ~ 5Fh.....	34
8.23	FAN Configuration Register - Index 80h.....	34
8.24	DC FAN1 Output Voltage Level Control Register (Manual Mode) /FAN1 Output Voltage Table (SMART FAN™ II Mode) – Index 81h.....	34
8.25	FAN1 Output Voltage Table (SMART FANTM II Mode) - Index 82h.....	35
8.26	TEMP0 (D+_D-) Target Temperature Register (Thermal Cruise Mode) / TEMP_POINT 1 for FAN1 (SMART FAN™ II Mode) - Index 83h.....	35
8.27	TEMP_POINT2 for FAN1 (SMART FANTM II Mode) - Index 84h.....	35
8.28	FAN 1 Speed Low Limit Rate Control Register (Thermal Cruise Mode) / TEMP_POINT3 for FAN1 (SMART FAN™ II Mode) - Index 85h.....	35
8.29	TEMP_POINT4 for FAN1 (SMART FANTM II Mode) - Index 86h.....	36
8.30	DC FAN2 Output Voltage Level Control Register (Manual Mode)/ FAN2 Output Voltage Table (SMART FAN™ II Mode) - 87h.....	36
8.31	FAN2 Output Voltage Table (SMART FANTM II Mode) - Index 88h.....	36
8.32	TEMP1 (VTIN1) Target Temperature Register (Thermal Cruise Mode) / TEMP_POINT 1 for FAN2 (SMART FAN™ II Mode) - Index 89h.....	37



8.33	TEMP_POINT2 for FAN2 (SMART FANTM II Mode) - Index 8Ah.....	37
8.34	FAN 2 Speed Low Limit Rate Control Register/ TEMP_POINT3 for FAN2 SMART FAN™ II Mode) - Index 8Bh	37
8.35	TEMP_POINT4 for FAN2 (SMART FANTM II Mode) - Index 8Ch.....	37
8.36	Tolerance of Temperature Register - Index 8Dh.....	38
8.37	FAN 2D/3D state Control Register - Index 8Eh.....	38
8.38	FAN Pre-Scale Register - Index 8Fh.....	38
8.39	FAN Initial Output Value – Index90h.....	39
8.40	Fan Step down Time Register - Index 91h.....	40
8.41	Fan Step up Time Register - Index 92h	40
8.42	Temperature Sensor 0 (D+_D-) Offset Register - Index 93h	40
8.43	Temperature Sensor 1 (VTIN1) Offset Register – Index94h.....	41
8.44	Temperature Sensor 2 (VTIN2) Offset Register - Index 95h	41
8.45	VRM9.0 High Tolerance Register - Index 96h	41
8.46	VRM9.0 Low Tolerance Register - Index 97h	42
8.47	Value RAM - Index 20h- 3Fh or 60h - 7Fh	42
9.	ELECTRICAL CHARACTERISTICS.....	44
9.1	Absolute Maximum Ratings.....	44
9.2	DC Characteristics	44
9.3	AC Characteristics.....	46
9.3.1	Serial Bus Timing Diagram.....	46
9.3.2	VID Input Skew.....	46
10.	THE TOP MARKING.....	47
11.	PACKAGE SPECIFICATION	48
12.	APPLICATION CIRCUITS	49



1. GENERAL DESCRIPTION

W83L786R/G is an evolving product of W83L785R -- Nuvoton's most popular hardware monitoring IC, and intelligent fan controlling IC. Specifically designed for the graphic cards and barebone / mini systems, W83L786R/G can be used to monitor several critical hardware parameters of the system, including voltages, fan speeds, and temperatures, which are very important for the system to work stably and properly.

W83L786R/G provides one set of 5-bit, VRM 9.0 compatible VID that could be used for GPU/CPU overclocking. By hardware trapping could set up the starting VID value. The W83L786R/G can monitor up to 5 analog voltage inputs, 2 fan tachometer inputs, and 3 remote temperature sensors. Two of the temperature inputs could be connected to CPU/GPU thermal diode sensors, and the other remote temperature sensor could be performed by thermistors. Power-on fan_set configuration offers the function to choose one of the four duty cycles, 100%, 81%, 62%, 43%, as initial fan speed. 2 sets of PWM (Pulse Width Modulation) / DC (Direct Current) fan output for SMART FAN™ control – “Thermal Cruise™” mode and “SMART FAN™ II” mode. Under “Thermal Cruise™” mode, temperatures of GPU and the system can be maintained within specific programmable ranges under the hardware control. Under “SMART FAN™ II” mode, the fan could be operated at the lowest possible speed for minimum acoustic noise, and the dynamic intelligent fan management could create the most quiet system environment and stable working performance. An 8-bit analog-to-digital converter (ADC) is built inside W83L786R/G. As for warning mechanism, W83L786R/G provides four pure hardware event pins for independent warning signals: VOLTAGE_FAULT#, FAN_FAULT#, TEMP_FAULT#, and INT#. All threshold values could be set for system protection without any timing delay. One bit power-on address selection is used to decide the address of the W83L786R/G over I²C serial bus interface. W83L786R/G also provides up to 14 optional multifunctional GPIO. Also, Watch Dog Timer™ could set up reset time flexibly; facilitate hardware management and monitoring. W83L786R/G is powered by 3.3V.

Through the application software or BIOS, the users can read all the monitored parameters of system from time to time. A pop-up warning can also be activated when the monitored item is out of the proper / preset range. The application software could be Nuvoton's Hardware Doctor™, Intel™ LDCM (LanDesk Client Management), or other management application software. Also the users can set up the upper and lower limits (alarm thresholds) of these monitored parameters and activate one programmable interrupts. For the spacing saving consideration of the Graphic cards and Notebook system, W83L786R/G is 28-pin SSOP package.



2. FEATURES

2.1 Monitoring Items

2.1.1 Temperature

- Measure the temperature with high accuracy.
- Two thermal diode sensor inputs (current mode) and one thermistor sensor input.
- Programmable hysteresis and setting points (alarm thresholds) for all monitored items.

2.1.2 Voltage

- 5 voltage sensor inputs.
--- Typically for Vcore, +3.3V (Power), RAM, AGP...etc.
- Five VID bits Intel VRM 9.0 compliant to set Vcore voltage for GPU overclocking.
- Watch Dog Timer with INT# output for overclocking failure recovery. (VID pins output control is also cleared by this INT#).
- Power on configuration for Vcore input.

2.1.3 Fan

- 2 sets of fan speed monitoring and controlling.
- 3D/2D application being used and transferring fan set to the most appropriate fan speed control.
- Fan set: power on configuration for fan speed at four rotation rate levels at 43%, 62%, 81%, and 100% duty cycle.
- Two DC/PWM fan output control.
- SMART FAN™ function compliant.

2.2 Actions Enabling

- Issue FAN_FAULT#, VOLTAGE_FAULT#, TEMP_FAULT#, and INT# signals to activate system protection.
- Warning signal pop-up in application software.

2.3 General

- Interface: I²C / SMBus control.
- 1 bit I²C address selection.
- Up to 14 GPIOs.
- Nuvoton hardware monitoring application software (Hardware Doctor™) support Windows 95 / 98 / 2000 / XP and Windows NT 4.0 / 5.0.
- 3.3V V_{CC} operation.

2.4 Package

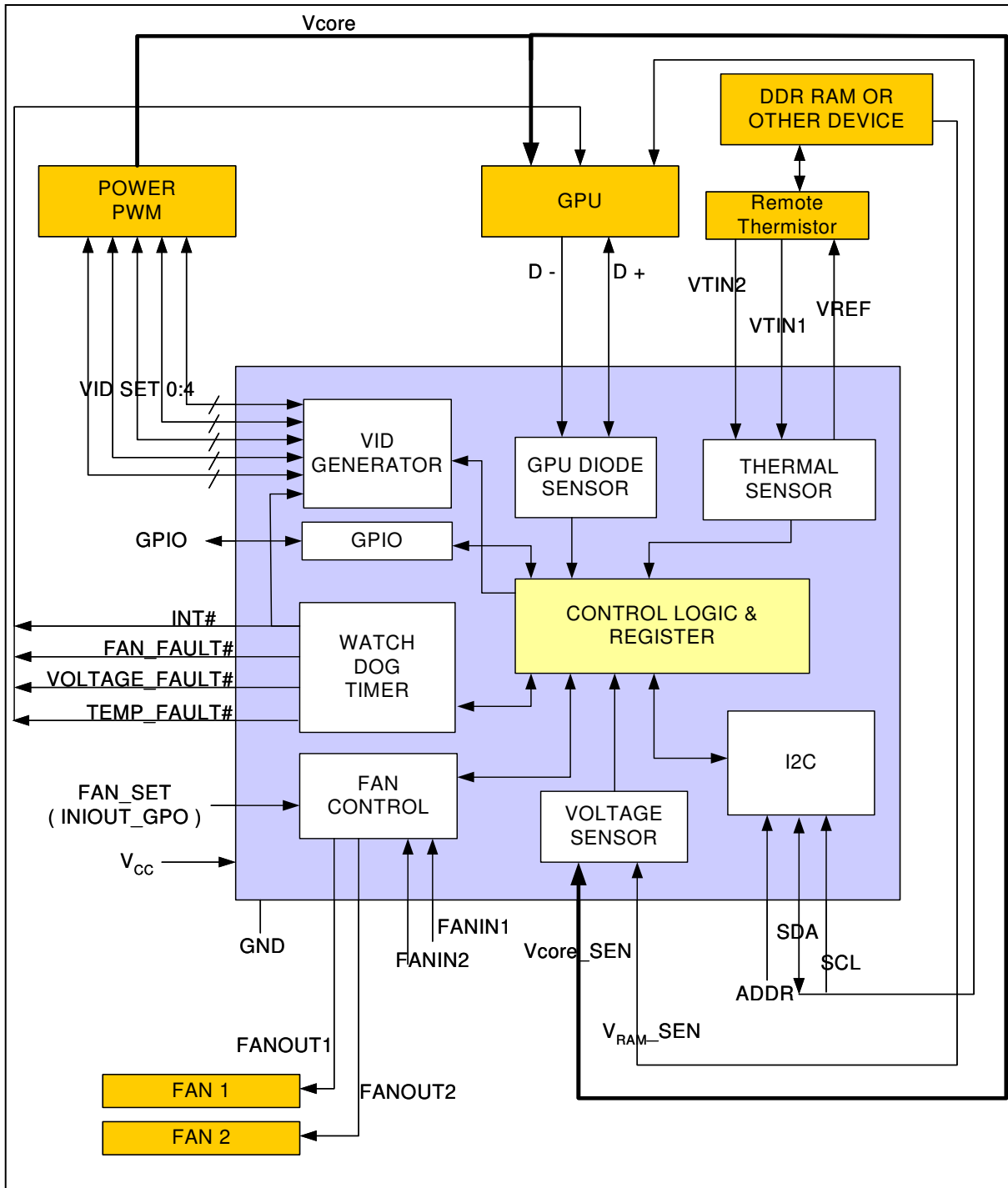
- 28-pin SSOP (209mil).



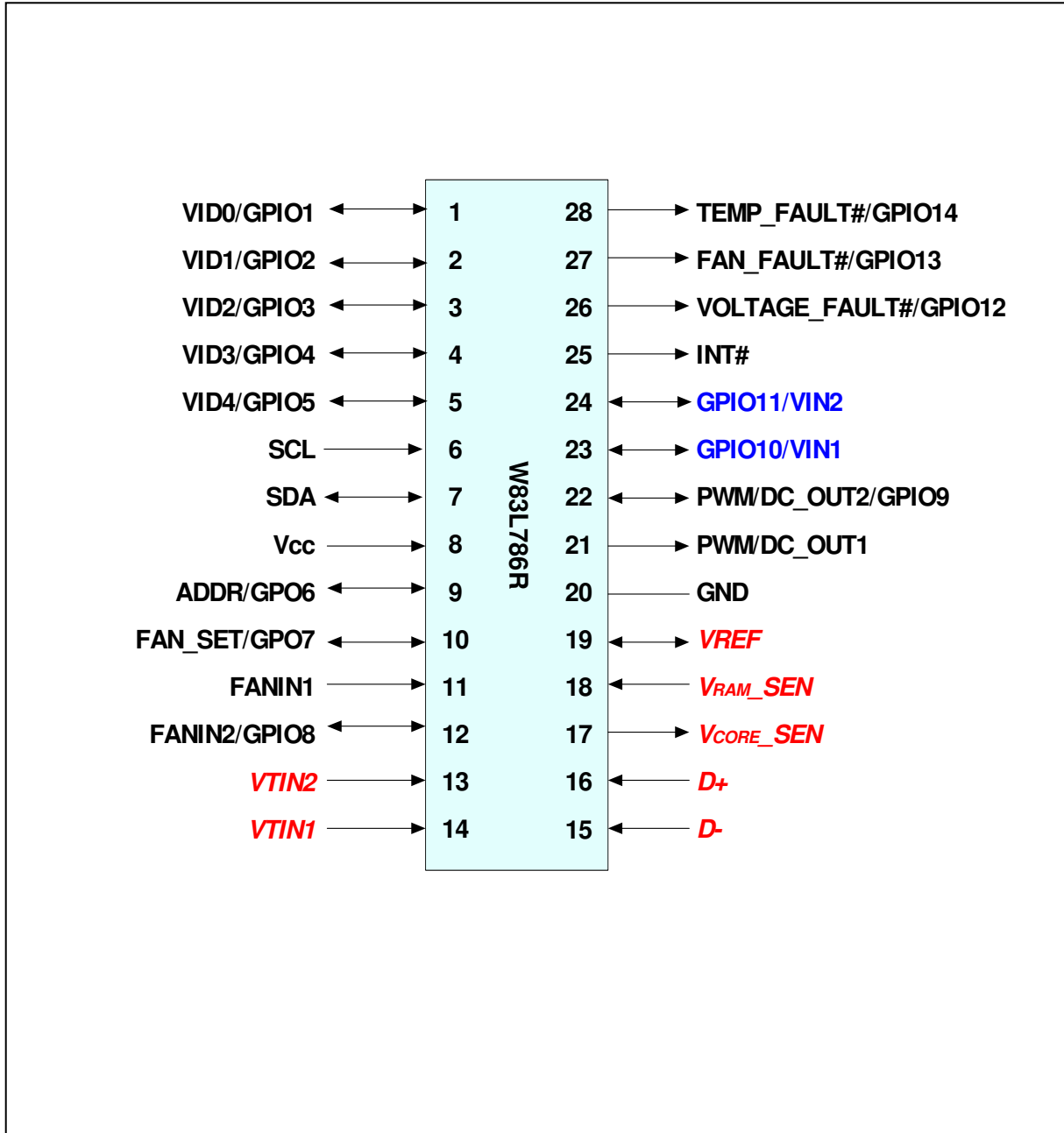
3. KEY SPECIFICATIONS

- | | |
|-----------------------------------|----------------------|
| ■ Voltage monitoring accuracy | ±3% (typ.) |
| ■ Monitoring temperature range | 0°C to +160°C |
| ■ Monitoring temperature accuracy | ± 3°C (max.) (@70°C) |
| ■ Supply voltage | 3.3V±10% |
| ■ Operating supply current | 2 mA typ. |
| ■ Power down supply current | 10 uA typ. |
| ■ ADC resolution | 8 Bits |

4. BLOCK DIAGRAM



5. PIN CONFIGURATION





6. PIN DESCRIPTION

PIN TYPE	PIN ATTRIBUTE
I/O _{12t}	TTL level bi-directional pin with 12 mA source-sink capability
I/O _{12ts}	TTL level and schmitt trigger with 12 mA source-sink capability
I/O _{8ts}	TTL level and schmitt trigger with 8 mA source-sink capability
I/O _{6ts}	TTL level and schmitt trigger with 6 mA source-sink capability
I/OD _{12ts}	TTL level and schmitt trigger open drain output with 12 mA sink capability
OUT ₁₂	Output pin with 12 mA source-sink capability
OD ₁₂	Open-drain output pin with 12 mA sink capability
AOUT	Output pin (Analog)
IN _t	TTL level input pin
IN _{ts}	TTL level input pin and schmitt trigger
AIN	Input pin(Analog)

PIN NAME	NO	PIN TYPE	DESCRIPTION
VID0 / GPIO1	1	I/OD _{12ts}	Digital Input (Open drain). Voltage supply readouts from GPU. This value is read into the VID register. General purpose I/O function. This multi-functional pin is programmable.
VID1 / GPIO2	2	I/OD _{12ts}	Digital Input (Open drain). Voltage supply readouts from GPU. This value is read into the VID register. General purpose I/O function. This multi-functional pin is programmable.
VID2 / GPIO3	3	I/OD _{12ts}	Digital Input (Open drain). Voltage supply readouts from GPU. This value is read into the VID register. General purpose I/O function. This multi-functional pin is programmable.
VID3 / GPIO4	4	I/OD _{12ts}	Digital Input (Open drain). Voltage supply readouts from GPU. This value is read into the VID register. General purpose I/O function. This multi-functional pin is programmable.



PIN description, continued.

PIN NAME	NO	PIN TYPE	DESCRIPTION
VID4 / GPIO5	5	I/OD _{12ts}	Digital Input (Open drain). Voltage supply readouts from GPU. This value is read into the VID register. General purpose I/O function. This multi-functional pin is programmable.
SCL	6	IN _{ts}	Digital Input (Open drain). SMBus serial clock input. Requires SMBus pull-up.
SDA	7	I/OD ₁₂	Digital I/O (Open drain). SMBus bidirectional serial data. Requires SMBus pull-up.
Vcc	8	POWER	Analog Input. Monitors +3.3V power supply.
ADDR / GPO6	9	IN _{TS} /OUT ₁₂	Determines the SMBus device address. General purpose I/O function. This multi-functional pin is programmable.
FAN_SET / GPO7	10	AIN/OUT ₁₂	Determines the FAN initial speed. General purpose Output function. This multi-functional pin is programmable.
FANIN1	11	IN _{TS}	0V to +3.3V amplitude fan tachometer input.(Default)
FANIN2 / GPIO8	12	IN _{TS} /OUT _{12TS}	0V to +3.3V amplitude fan tachometer input.(Default) / General purpose I/O function. This multi-functional pin is programmable.
VTIN2	13	AIN	Analog Input.
VTIN1	14	AIN	Analog Input. This pin could connect to thermister or thermal diode. Regard as anode connection if connected to thermal diode; share cathode with D-.
D-	15	AIN	Cathode Connection to GPU Thermal Diode.
D+	16	AIN	Anode Connection to GPU Thermal Diode.
V_{CORE_SEN}	17	AIN	Analog Input. Monitors GPU core voltage (0V-3V).



PIN description, continued.

PIN NAME	NO	PIN TYPE	DESCRIPTION
V _{RAM_SEN}	18	AIN	Analog Input. Monitors RAM's voltage.
VREF	19	AOUT	Reference voltage.
GND	20	GROUND	Ground pin for the W83L786R
PWM/DC OUT1	21	OD ₁₂ /OUT ₁₂ /AOUT	Fan speed control output. This pin is default DC output level. It can be programmed as PWM output.
PWM/DC OUT2 / GPIO9	22	OD ₁₂ /AOUT/IOD _{12TS}	Fan speed control output. This pin is default DC output level. It can be programmed as PWM output. General purpose I/O function. This multi-functional pin is programmable.
VIN1/GPIO 10	23	AIN/IOD _{12TS}	Analog Input. Monitors voltage. General purpose I/O function.
VIN2/GPIO11	24	AIN/IOD _{12TS}	Analog Input. Monitors voltage. General purpose I/O function.
INT#	25	OD ₁₂	System Interrupt.
VOLTAGE_FAULT# / GPIO12	26	OD ₁₂ /IOD _{12TS}	Active-Low output. This pin will be a logic LOW when the voltage exceeds its high/low limit. (Default) General purpose I/O function. This multi-functional pin is programmable.
FAN_FAULT# / GPIO13	27	OD ₁₂ /IOD _{12TS}	Active-Low output. This pin will be a logic LOW when the Fan1 or fan2 is abnormally stopped. (Default) General purpose I/O function. This multi-functional pin is programmable.
TEMP_FAULT# / GPIO14	28	OD ₁₂ /IOD _{12TS}	Active-Low output. This pin will be a logic LOW when the temperature of the system or GPU exceeds its limit. (Default) General purpose I/O function. This multi-functional pin is programmable.



7. FUNCTIONAL DESCRIPTION

7.1 General Description

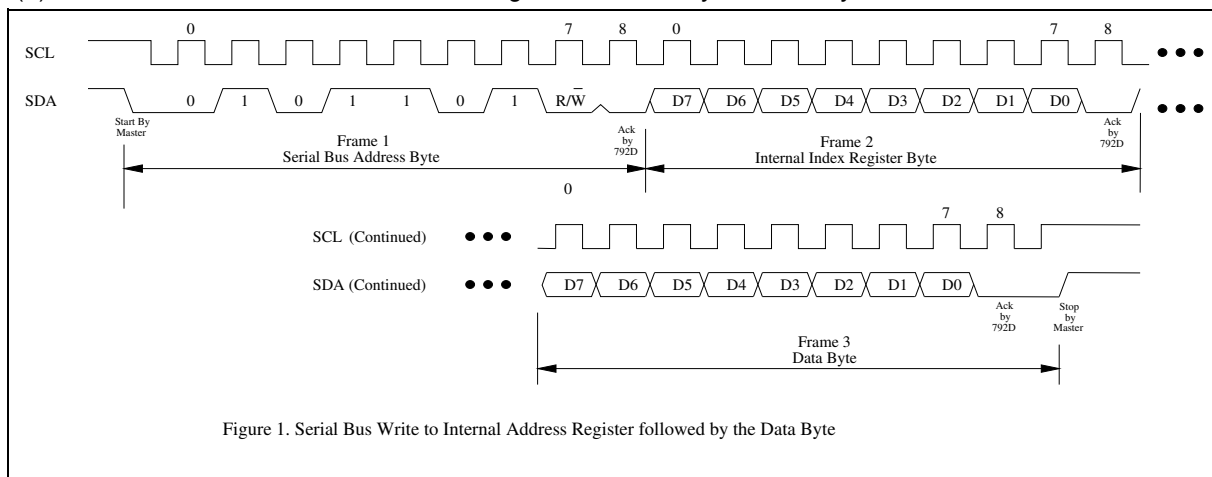
W83L786R/G provides 5 analog voltage inputs, 2 fan speed input monitoring and output controls which support both PWM (Pulse Width Modulation) fan control and DC (Direct Current) fan control, all of them being implemented with SMART FAN™ I and SMART FAN™ II, and 3 sets of thermal inputs for remote thermistors and GPU thermal diode sensor. W83L786R/G is I²C / SMBus interface compatible. 1 set of 5-bit VID input/output for processor VID table could be selected by hardware trapping for VRM9.0 specifications. Furthermore, the Watch Dog Timer will monitor every function and store the values to registers for comparison with preset ranges. If the monitored value exceeds the limit value, the interrupt status will be set to 1 and W83L786R/G will issue interrupt signals such as INT# and IRQ if not masked. W83L786R/G also provides software and hardware Watch Dog Timer to avoid system hang on.

7.2 Access Interface

W83L786R/G provides I²C Serial Bus for microprocessor to read/write internal registers, and the I²C address default value is 01011110b (Pin 9 pull high). If Pin 9 pulls low, the I²C address value is 01011100b.

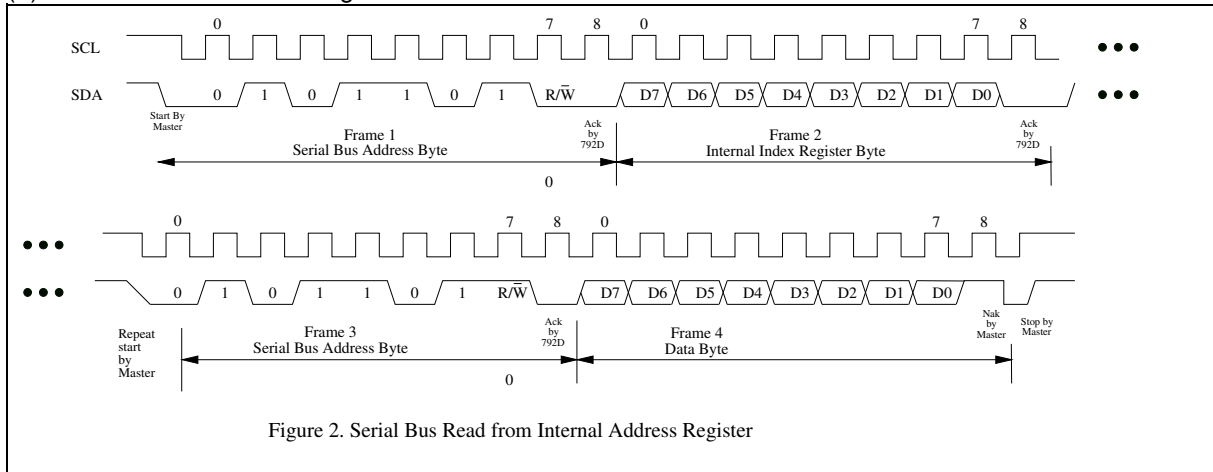
7.3 The First Serial Bus Access Timing

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



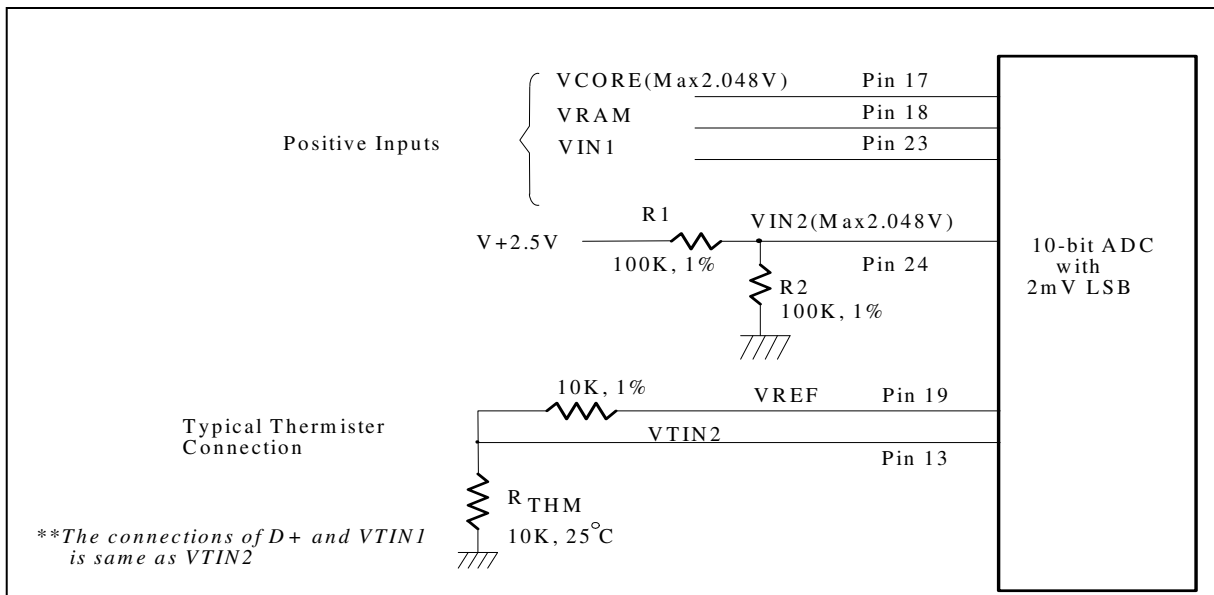


(b) Serial bus read from a register



7.4 Analog Inputs

The maximum input voltage of the analog pin is 2.048V because the 8-bit ADC has the 2mv LSB. Actually, the application of the voltage monitoring would most often be connected to power suppliers. The input voltage lower than 2.048V could directly connect to the analog inputs. The inputs voltage higher than 2.048V should be reduced by external resistors so as to meet the input range. This is shown in Figure 3.



7.4.1 Voltage Input can not be over 2.048V

The input voltage Vcore , Vram, VIN1 and VIN2 can be expressed as following equation:

$$VIN2 = V_{+2.5V} \times \frac{R_2}{R_1 + R_2} \quad . \quad V_{+2.5V} \text{ is } +2.5V \text{ inputs.}$$

The value of R1 and R2 can be selected to 100K Ohms and 100K Ohms, respectively, when the input voltage is 2.5V. The node voltage of VIN2 can be subject to less than 2.048V for the maximum input range of the 8-bit ADC. The pin 8 is connected to the power supply VCC with +3.3V. There are two functions in this pin with 3.3V: the first function is to supply internal analog power of W83L786R/G and the second function is to connect this pin to internal serial resistors to monitor the +3.3V voltage. The values of two serial resistors are 20K ohms and 40K ohms so that input voltage to ADC is 1.1V which is less than 2.048V of ADC maximum input voltage. The express equation can represent as follows.

$$V_{in} = VCC \times \frac{20K\Omega}{20K\Omega + 40K\Omega} \cong 1.1V$$

where VCC is set to 3.3V.

7.4.2 Voltage Fault (VOLTAGE_FAULT #)

W83L786R/G provides a good protection for voltage. Set Pin 26 (VOLTAGE_FAULT#) to monitor voltage. When Vcore (Pin17), Vram (Pin18), VIN1 (Pin23), VIN2 (Pin24), or VCC (Pin8) voltage exceeds high or low voltage limit in VR2B ~ VR34, Pin 26 VOLTAGE_FAULT# will be asserted (Figure 4).

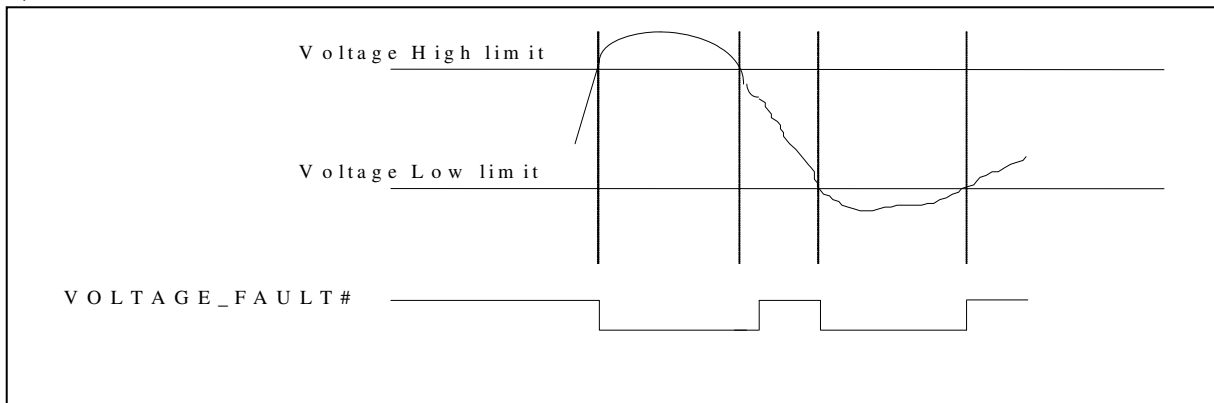


Figure 4. Voltage Fault

7.5 Temperature Measurement Machine

The temperature data format is 8-bit unsigned for thermal sensor. The 8-bit temperature data can be obtained by reading the VR [25h], VR [26h] or VR [27h]. The format of the temperature data is shown in Table 1.

TEMPERATURE	8-BIT DIGITAL OUTPUT	
	8-BIT BINARY	8-BIT HEX
+160°C	1010,0000	A0h
+25°C	0001,1001	19h
+2°C	0000,0010	02h
+1°C	0000,0001	01h
+0°C	0000,0000	00h

Table 1

7.5.1 Monitor Temperature from Thermistor

W83L786R/G can connect two thermistors and one thermal diode sensor to measure three different environment temperatures. The specification of thermistor should be considered to (1) β value is 3435 K, and (2) resistor value is 10K ohms at 25°C. In the Figure 3, the themistor is connected by a serial resistor with 10K Ohms, and then connect to V_{REF} (pin 19).

7.5.2 Monitor Temperature from Thermal Diode

W83L786R/G can alternate the thermistor to thermal diode interface and the circuit connection is shown as Figure 5. The pin of D- is connected to power supply ground (GND) and the pin D+ is connected to pin D+ or VTIN1 in the W83L786R/G. The bypass capacitor $C=2200\text{pF}$ should be added to filter the high frequency noise.

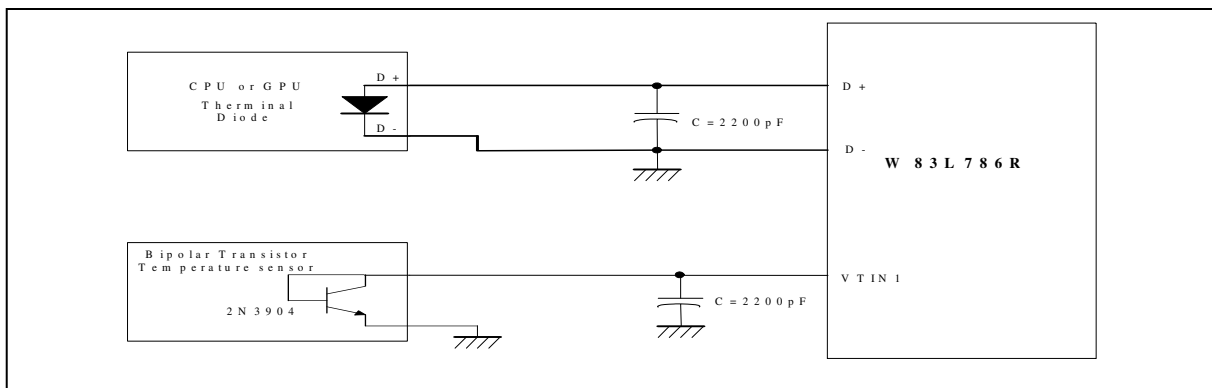


Figure 5

7.5.3 Temperature Fault (TEMP_FAULT #)

W83L786R/G provides a good protection for temperature fault. Set Pin 28 (TEMP_FAULT#) to monitor temperature. When D+-D- (Pin16, 15), VTIN1 (Pin14), or VTIN2 (Pin13) temperature exceeds temperature fault limit in VR35, VR37, or VR39, Pin 28 TEMP_FAULT# will be asserted (Figure 6).

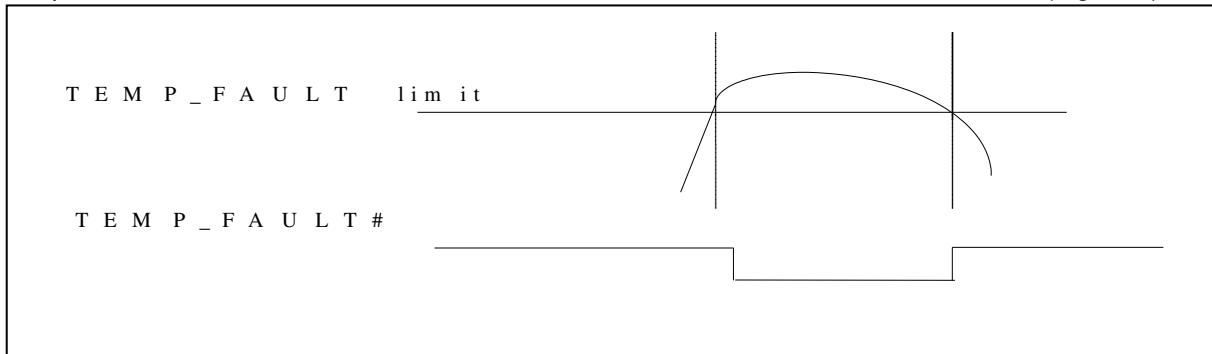


Figure 6. TEMP_FAULT

7.6 FAN Speed Count and FAN Speed Control

7.6.1 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 VCC. If the input signals from the tachometer outputs are over the VCC, the external trimming circuit should be added to reduce the voltage to obtain the input specification. The normal circuit and trimming circuits are shown in Figure 7.

Determine the fan counter according to:

$$Count = \frac{1.35 \times 10^6}{RPM \times Divisor}$$

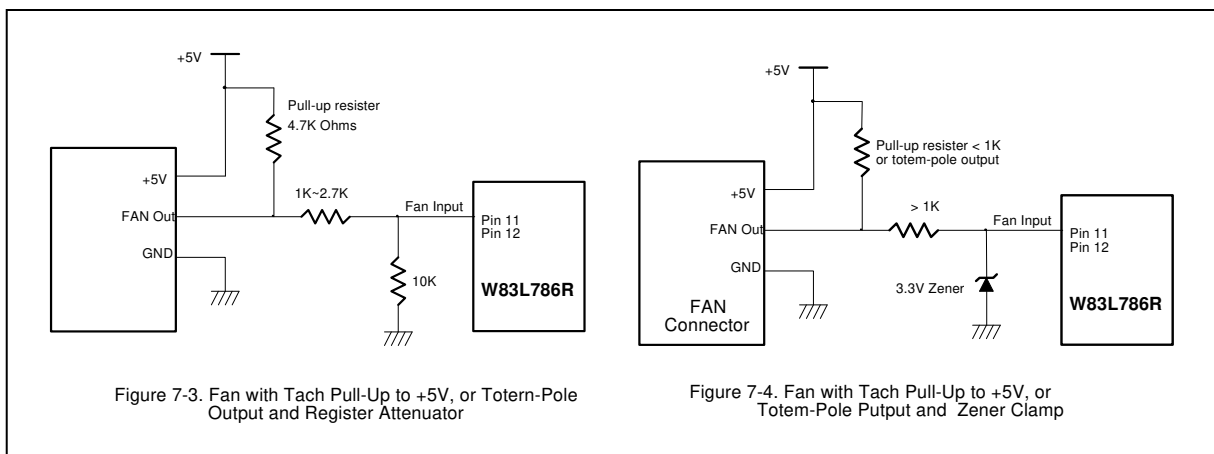
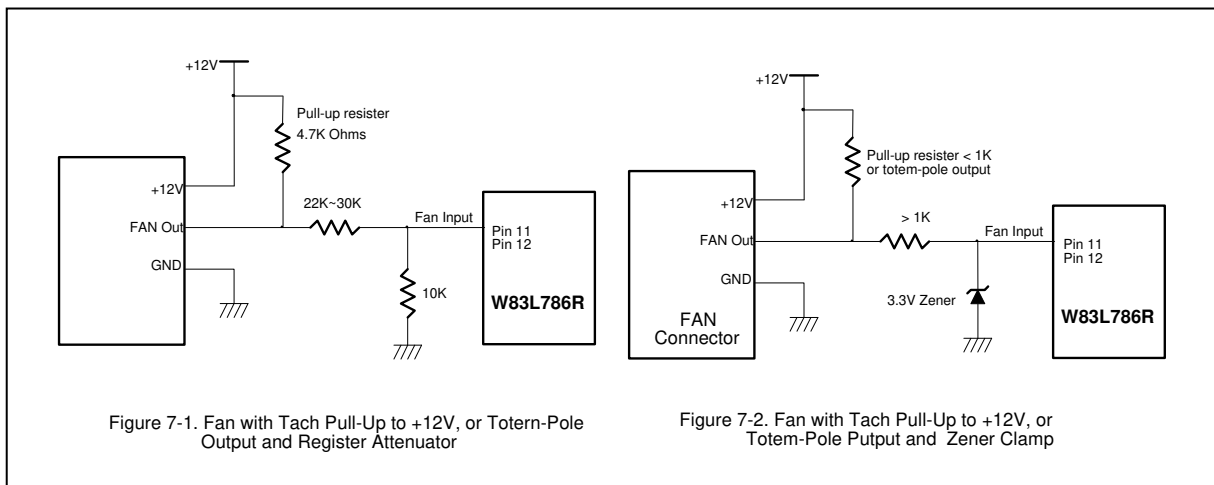
In other words, the fan speed counter has been read from register VR28 or VR29, and the fan speed can be evaluated by the following equation.

$$RPM = \frac{1.35 \times 10^6}{Count \times Divisor}$$

The default divisor is 2 and defined at CR54.bit0~2, bit4~6 which are three bits for divisor. That provides very low speed fan counter such as power supply fan. Table 2 is an example for the relation of divisor, RPM, and count.

DIVISOR	NOMINAL RPM	TIME PER REVOLUTION	COUNTS	70% RPM	TIME FOR 70%
1	8800	6.82 ms	153	6160	9.74 ms
2 (default)	4400	13.64 ms	153	3080	19.48 ms
4	2200	27.27 ms	153	1540	38.96 ms
8	1100	54.54 ms	153	770	77.92 ms
16	550	109.08 ms	153	385	155.84 ms
32	275	218.16 ms	153	192	311.68 ms
64	137	436.32 ms	153	96	623.36 ms
128	68	872.64 ms	153	48	1246.72 ms

Table 2

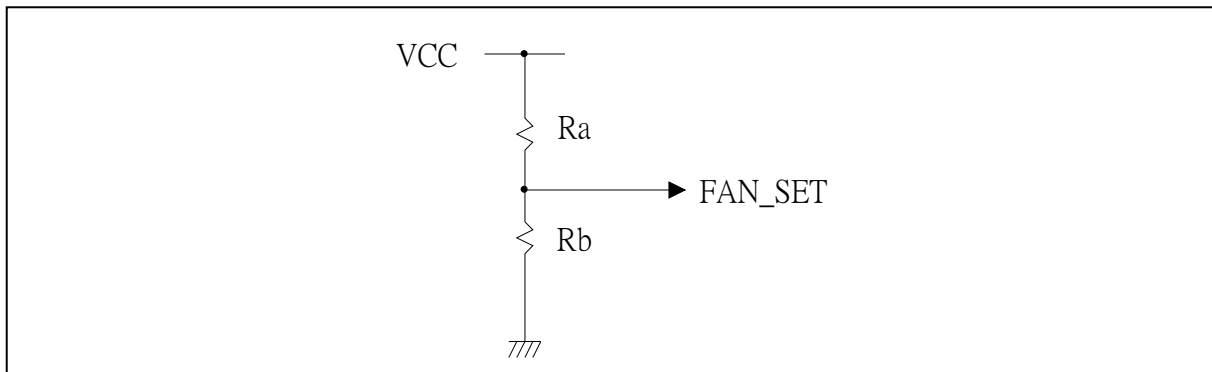


7.6.2 Fan Speed Control

W83L786R/G provides two sets for PWM/DC fan speed control. The duty cycle of PWM or the output voltage of DC can be programmed by a 4-bit register. There are four mode to control fan speed which are set by programming CR80 [3:2] and CR [5:4], and default are FAN_SET mode.

7.6.2.1. Default Fan Speed Setting

There is a pin to set the default value for fan speed control by adjusting external serial resistors. After power up, the default value will be stored in CR90 (FAN_SET mode). The figure and table are shown below.



SECTION	FAN SPEED RATE	RA	RB
3	100%	9.1K	×
2	81%	4.7K	9.1K
1	62%	9.1K	4.7K
0	43%	×	9.1K

Figure 8 OFFSET Setting

7.6.2.2. PWM Mode

$$\text{Duty - cycle(\%)} = \frac{\text{Programmed 4 - bit Register Value}}{16} \times 100\%$$

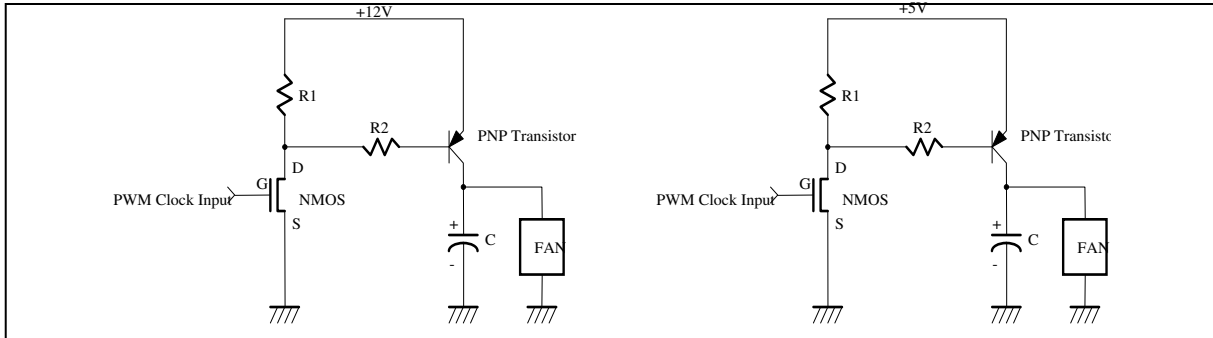


Figure 9

7.6.2.3. DC Mode

W83L796R/G has a 4-bit DAC, which produces 0 to 3.3 voltages DC output that provides maximum 2 sets for fan speed control. The analog output can be programmed in the CR 81, and CR 87 (manual mode). The expression of output voltage can be represented as follows,

$$\text{OUTPUT Voltage} = VCC \times \frac{\text{Programmed 4-bit Register Value}}{16}$$

The application circuit is shown as follow,

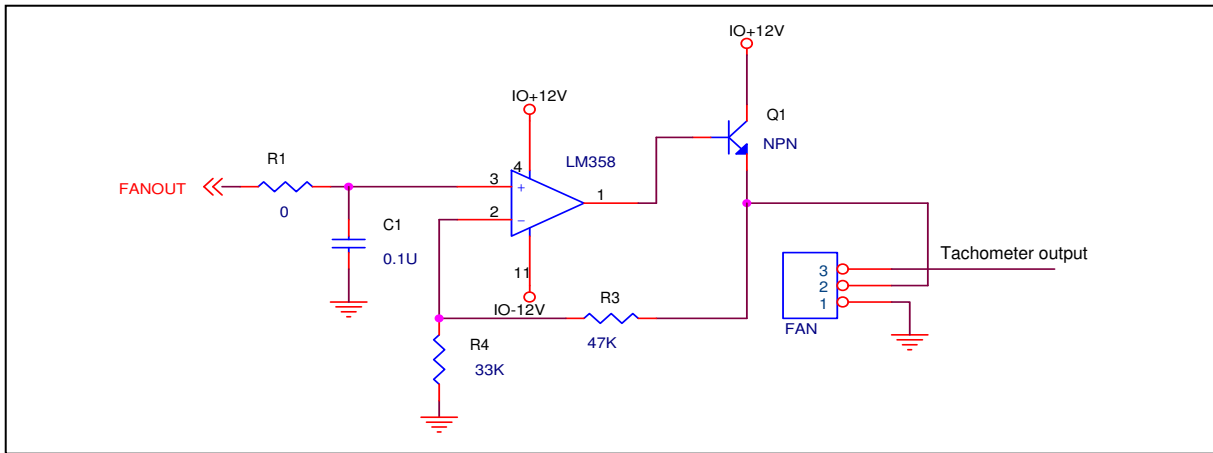


Figure 10

Must be take care when choosing the OP-AMP and the transistor. The OP-AMP is used for amplify the 5V range of the DC output up to 12V. The transistor should has a suitable β value to avoid its base current pulling down the OP-AMP 's output and gain the common current to operate the fan at fully speed. (For more cost and effort efficient solution please refer to W83391TS/QS – the DC fan pre-driver that could provide up to 24V gate voltage for external N-channel MOSFET driving)

7.6.3 SMART FAN™ I Control

W83L786R/G supports two sets SMART FAN™ I function and mapping to D+,D- (PWM/DC_OUT1), VTIN1 (PWM/DC_OUT2) . If CR80 [3:2] or CR80 [5:4] set to 2'b10, Fan1 or Fan2 will enable SMART FAN™ I function.

At this mode, W83L786R/G provides the SMART FAN™ system to automatically control fan speed to keep the temperatures of CPU and the system within specific range. At first a wanted temperature and interval must be set (ex. $55\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$) by BIOS and the fan speed will be lowered as long as the current temperature remains below the setting value. Once the temperature exceeds the high limit (58°C), the fan will be turned on with a specific speed set by BIOS (ex: 80% duty cycle) and automatically controlled its PWM duty cycle with the temperature varying. Three conditions may occur:

- (1) If the temperature still exceeds the high limit (ex: 58°C), PWM duty cycle will increase slowly. If the fan has been operating in its full speed but the temperature still exceeds the high limit (ex: 58°C), a warning message will be issued to protect the system.
- (2) If the temperature goes below the high limit (ex: 58°C), but still above the low limit (ex: 52°C), the fan speed will be fixed at the current speed because the temperature is in the target range (ex: $52\text{ }^{\circ}\text{C} \sim 58^{\circ}\text{C}$).
- (3) If the temperature goes below the low limit (ex: 52°C), PWM duty cycle will decrease slowly to 0 or a preset stop value until the temperature exceeds the low limit.

Figure 11-1, 11-2 gives an illustration of Thermal Cruise Mode.

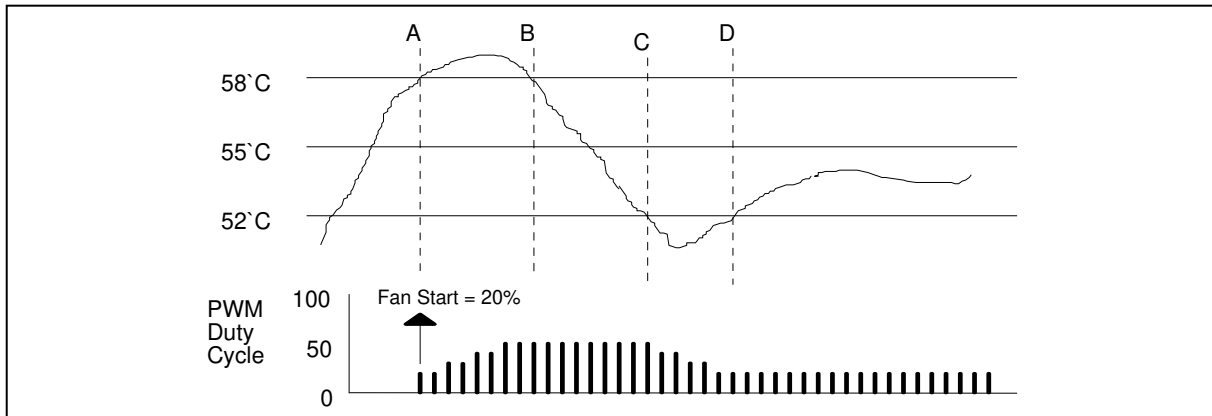


Figure 11-1

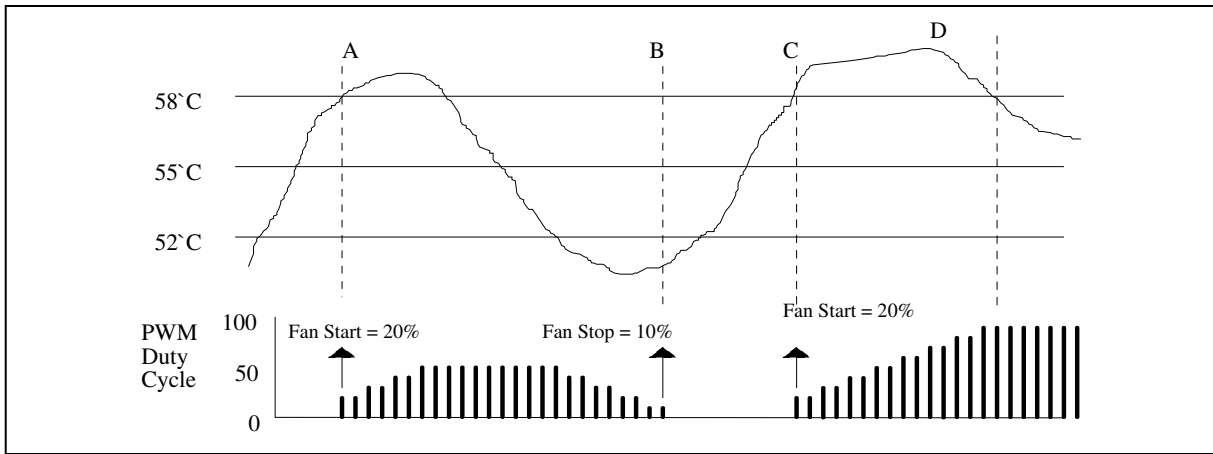


Figure 11-2

Of course, SMART FAN™ control system can be disabled and the fan speed control algorithm can be programmed by BIOS or application software.

7.6.4 SMART FAN™ II Control

W83786R/G provide 4 temperature points each can automatically control PWM or DC fan mode. Each temperature maps different fan out level, the relationship is shown as follows:

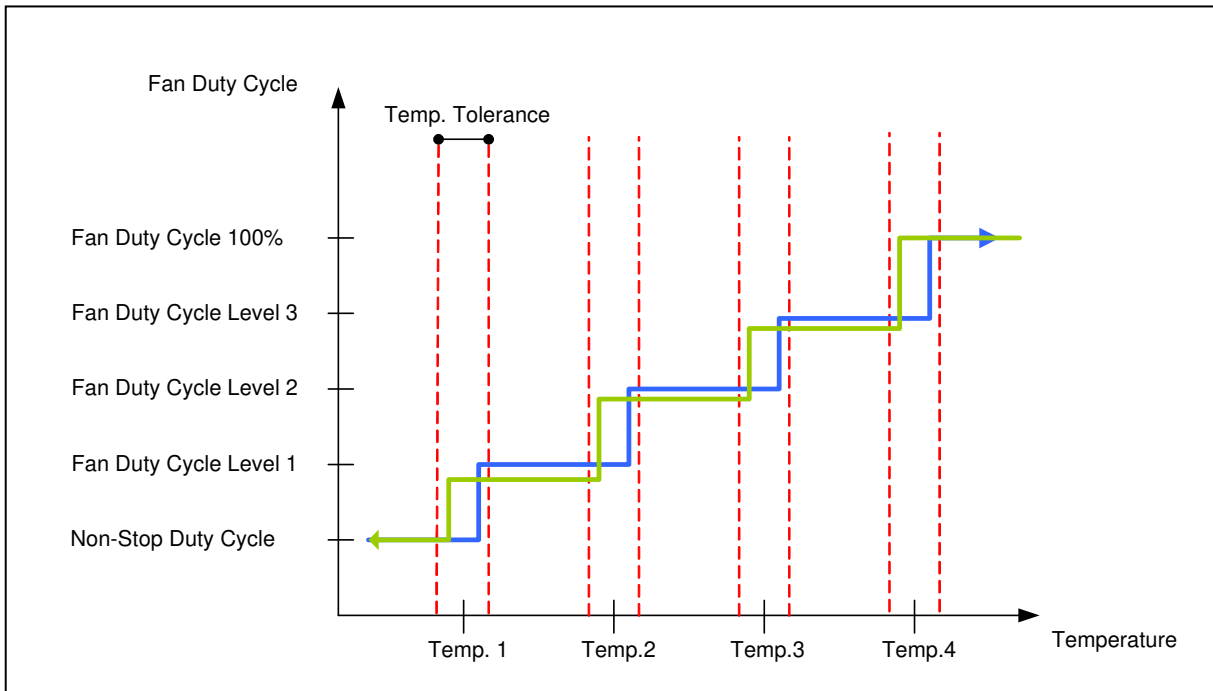


Figure 12 SMART FAN™ II behaviors



The SMART FAN™ II, a new innovation of Nuvoton, is specifically designed to operate fans at the lowest possible speed so as to minimize acoustic noise. As the figure shown above, it is clear that SMART FAN™ II describes a relationship between Fan PWM Duty Cycle/DC Level and temperature. Users can program CR [84h] to enable SMART FAN™ II mode. SMART FAN™ II registers allow users to define suitable fan output levels to improve acoustic noise, power consumption and reliability issues regarding to specific fan.

Each fan has 4 duty cycle registers and 4 temperature point registers to setup the relation between fan output and temperature. Tolerance registers CR [87h], CR [97h] are used to postpone the response of fan output and avoid fan output throttles at each temperature point because fan throttling might produce some undesired noise.

The mechanism of SMART FAN™ II is described as follows:

- (1) At first, the fan speed operates at Non-Stop Duty Cycle, and keeps constant while temperature rises. When rising temperature hits critical Temp.1, fan speed remains unchanged. If the temperature keeps on rising and finally hits the upper edge of Temp. Tolerance of Temp.1, it triggers the fan speed change mechanism and fan speed jumps from Non-Stop Duty Cycle to Fan Duty Cycle Level 1.
- (2) Fan speed remains constant at Fan Duty Cycle Level 1 even though the monitored temperature hits Temp.2.
- (3) Fan speed will directly jump from Fan Duty Cycle Level 1 to Fan Duty Cycle Level 2 while the monitored temperature hits the upper edge of Temp. Tolerance of Temp.2.
- (4) Same mechanism happens between Temp.3 and Temp.4.
- (5) If the monitored temperature between Temp.3 and Temp.4, for example, begins to fall, the fan will keep its speed at Fan Duty Cycle Level 3, which is a constant.
- (6) If the monitored temperature keeps on falling, the fan speed still remains the same unless the temperature hits the lower edge of Temp. Tolerance of Temp.3.
- (7) Once the monitored temperature hits the lower edge of Temp. Tolerance of Temp.3, the fan speed reduces directly from Fan Duty Cycle Level 3 to Fan Duty Cycle Level 2, and keeps the same speed until the temperature hits the next lower edge of Temp. Tolerance.

REGISTER	TEMP 1 – FAN1	TEMP 2 – FAN2	TEMP 3 – FAN3
Non-Stop Duty Cycle	CR[88h] b3:b0	CR[89h] b3:b0	CR[98h] b3:b0
Duty Level 1	CR[88h] b7:b4	CR[89h] b7:b4	CR[98h] b7:b4
Duty Level 2	CR[E0h] b7:b4	CR[E1h] b7:b4	CR[E2h] b7:b4
Duty Level 3	CR[E0h] b3:b0	CR[E1h] b3:b0	CR[E2h] b3:b0
Temp Point 1	CR[85h] b7:b0	CR[86h] b7:b0	CR[96h] b7:b0
Temp Point 2	CR[E3h] b7:b0	CR[E6h] b7:b0	CR[E9h] b7:b0
Temp Point 3	CR[E4h] b7:b0	CR[E7h] b7:b0	CR[EAh] b7:b0
Temp Point 4	CR[E5h] b7:b0	CR[E8h] b7:b0	CR[EBh] b7:b0
Tolerance	CR[87h] b3:b0	CR[87h] b7:b4	CR[97h] b3:b0

7.6.5 Fan Fault (FAN_FAULT #)

W83L786R/G provides a good protection for fan speed. Set Pin 27 (FAN_FAULT#) to monitor fan speed. When FANIN1 (Pin11) or FANIN2 (Pin12) exceeds fan count high limit in VR3B or VR3C. Pin27 FAN_FAULT# will be asserted (Figure 13).

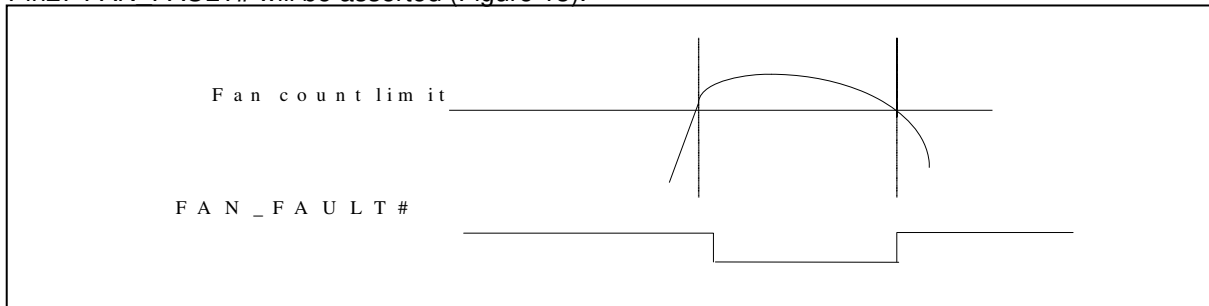


Figure 13. FAN_FAULT

7.7 Fault Signal—INT#

7.7.1 Temperature

Pin INT# for temperature has 3 modes.

7.7.1.1. Comparator Interrupt Mode

Temperature exceeding T_O causes an interrupt and this interrupt will be reset when reading all of the Interrupt Status Registers. Once an interrupt event has occurred by exceeding T_O , then reset, if the temperature remains above the T_{HYST} , the interrupt will occur again when the next conversion has completed. If an interrupt event has occurred by exceeding T_O and not reset, the interrupts will not occur again. The interrupts will continue to occur in this manner until the temperature goes below T_{HYST} . (Figure 14-1)