

NCT7509Y

NCT7509W

**Nuvoton Thermal Sensor IC
with Fan Control**

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1. GENERAL DESCRIPTION

The NCT7509 is a Nuvoton Hardware Monitor IC, contains 1 remote and 1 on-die temperature sensor and 1 fan controller with SMBus[™] interface. The remote sensor is diode-connected transistor, such as 2N3904 or the thermal diode integrated in Computer Processor Units (CPU) and Graphics Processor Units (GPU). The NCT7509 also supports offset adjust register to correct the errors that caused by different thermal diodes.

The fan controller in NCT7509 support PWM (pulse width modulation) fan output modes for Nuvoton SMART FAN[™] control - “Thermal Cruise[™]” mode and “SMART FAN[™] IV” mode. In the “Thermal Cruise[™]” mode, temperatures of CPU/GPU and the system can be maintained within specific programmable ranges under the hardware control. SMART FAN[™] IV provides 8 sets of temperatures setting points to program 6 slopes linear fan speed vs. temperature transfer function. NCT7509 also supports close-loop fan controller based on RPM. The NCT7509 provides an easy to implement cooling and quiet solution with maximum safety and flexibility.

The NCT7509 supports 2 wire alert signals which ALERT# is for processor event notification and T_CRIT is for thermal shutdown.

2. FEATURES

2.1 Fan Speed Monitoring and Control

- Support 256 steps PWM modes fan speed control
- Thermal Cruise[™] and SMART FAN[™] IV to control the fan speed
- Enhanced Smart Fan algorithm, SMART FAN[™] IV, supports multi-tracking of fan control vs. temperature and registers for each fan control output.
- Closed-loop fan controller via RPM setting
- Manual Mode for specific application

2.2 Temperature Measurement

- Measure the temperature with high accuracy
- One local on-die thermal sensor
- One remote temperature sensor with current mode

2.3 Event Notification

- Supports 2 alert outputs : ALERT# and T_CRIT#
- Event notification via ALERT# signal for over temperature and fan error
- ALERT# output supports SMBus[™] 2.0 ARA function
- T_CRIT# point supports Hardware Power-on setting

2.4 General

- I²C® Compatible System Management bus (SMBus[™])
- 3.3V±5% VDD operation
- 10-pin MSOP and DFN Green Package (Halogen-free)

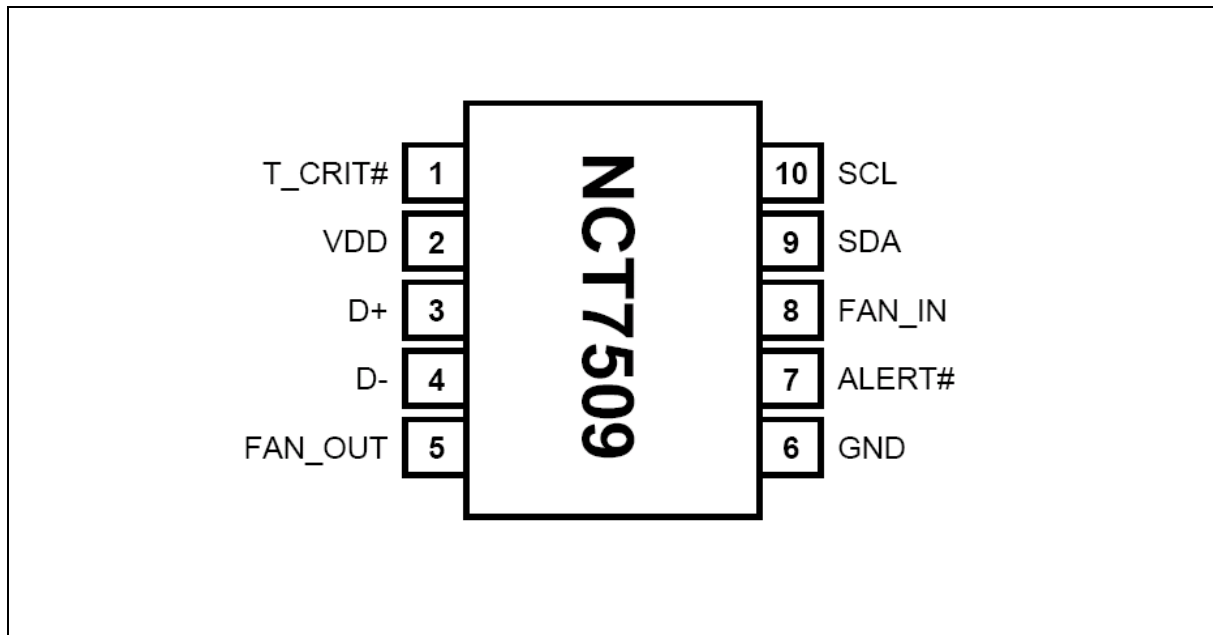
3. KEY SPECIFICATIONS

PARAMETER	RATING
Local temperature range and accuracy	-40°C to +125°C
	Typ. $\pm 2^{\circ}\text{C}$ (20°C~40°C)
	Max. $\pm 3^{\circ}\text{C}$ (-40°C~125°C)*1
Remote temperature range and accuracy	-40°C to +127°C
	Typ. $\pm 1^{\circ}\text{C}$ (25°C ~70°C)
	Typ. $\pm 2^{\circ}\text{C}$ (-40°C ~127°C)
	Max. $\pm 3^{\circ}\text{C}$ (-40°C~127°C)*2
Supply voltage	3.3V $\pm 5\%$
Operating supply current	3 mA typ.
ADC resolution include sign bit	10 Bits

*1 Guaranteed by design from -40~125 degreeC, 100% tested at 85 degreeC.

*2 Guaranteed by design from -40~127 degreeC, 100% tested at 85 degreeC.

4. PIN CONFIGURATION



5. PIN DESCRIPTION

5.1 PIN TYPE DISCRIPTION

PIN TYPE	PIN ATTRIBUTE
OD ₁₂	Open-drain output pin with 12 mA sink capability
IN _{ts}	TTL level input pin and schmitt trigger
AIN	Input pin (Analog)
P	Power or Ground Pin

5.2 PIN DISCRIPTION

PIN NO.	PIN NAME	I/O	FUNCTION
1	T_CRIT#	OD ₁₂	T_CRIT alarm output, for interrupt or shutdown control
2	VDD	P	DC Power supply, Voltage input 3.3V±5%
3	D+	AIN	Connect to Thermal Diode Anode
4	D-	AIN	Connect to Thermal Diode Cathode
5	FAN_OUT	OD ₁₂	Fan speed control PWM output
6	GND	P	Power supply ground
7	ALERT#	OD ₁₂	Alarm output, for interrupt control
8	FAN_IN	IN _{ts}	Fan tachometer input
9	SDA	IN _{ts} / OD ₁₂	SMBus™ bi-directional data
10	SCL	IN _{ts}	SMBus™ Clock

6. FUNCTION DESCRIPTION

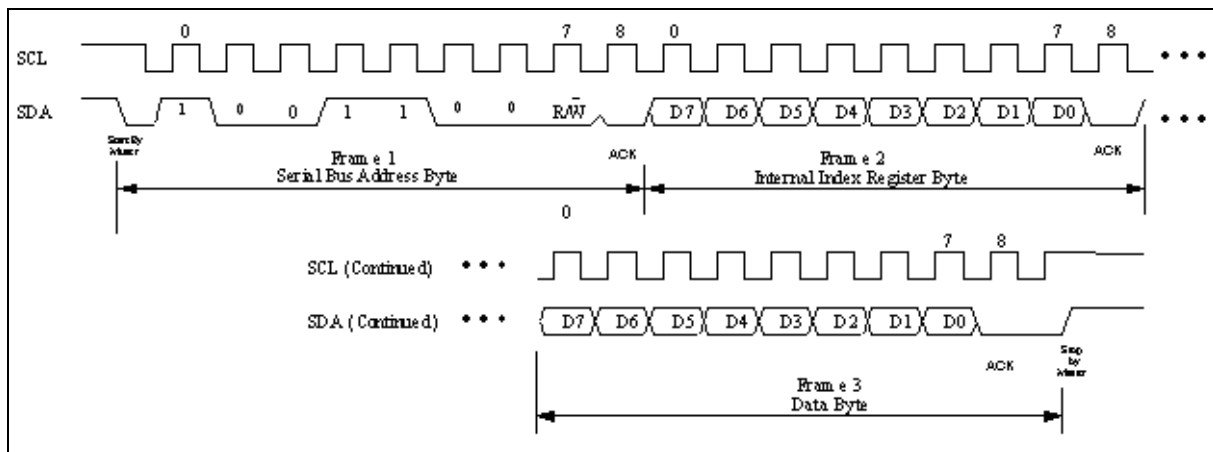
6.1 General Description

NCT7509 is SMBus™ interface device to provides on-die temperature sensor and 1 set of thermal inputs for CPU/GPU thermal diode sensor, 2 wire alert signals which ALERT# is for processor event notification and T_CRIT# is for thermal shutdown, 1 set fan speed input and output which support PWM (Pulse Width Modulation) fan control.

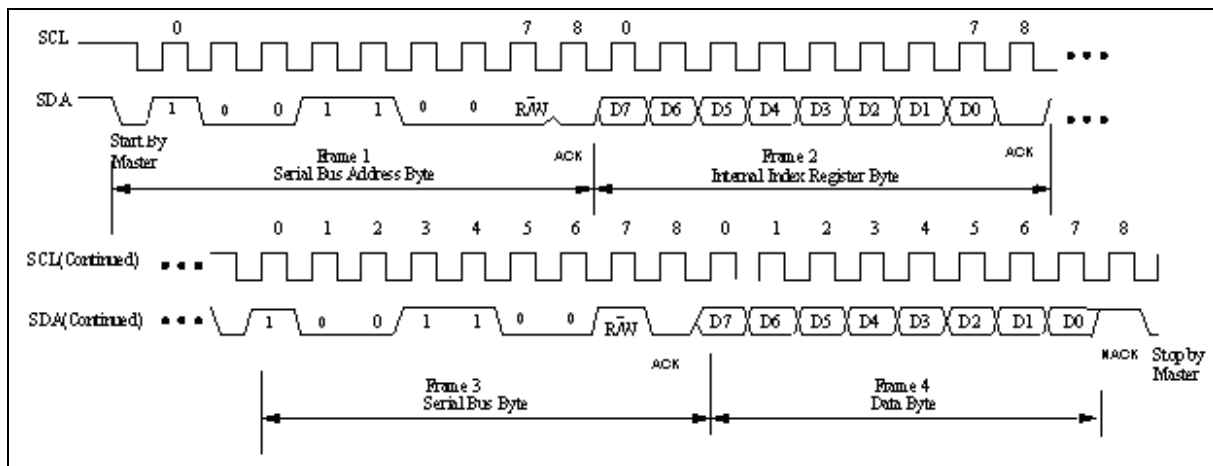
6.2 Access Interface

NCT7509 provides SMBus™ to access the internal register. It supports SMBus™ byte write and byte read protocols.

6.2.1 Data write to the internal register



6.2.2 Data read from the internal register



6.3 Address Setting

NCT7509 I2C/SMBus™ address is 1001100xb (x is R/W bit).

6.4 Temperature Measurement Data Format

6.4.1 The local temperature (on-die) data with 8-bit 2`s complement format.

TEMPERATURE	8-BIT DIGITAL OUTPUT
+127°C	0111,1111
+25°C	0001,1001
+2°C	0000,0010
+1°C	0000,0001
+0°C	0000,0000
- 1°C	1111,1111
- 2°C	1111,1110
- 25°C	1110,0111
- 128°C	1000,0000

6.4.2 The remote temperature data with 11-bit 2`s complement format.

TEMPERATURE	8-BIT DIGITAL OUTPUT HIGH BYTE	3-BIT DIGITAL OUTPUT LOW BYTE
+127.875°C	0111,1111	111X,XXXX
+25.750°C	0001,1001	110X,XXXX
+2.250°C	0000,0010	010X,XXXX
+1.125°C	0000,0001	001X,XXXX
+0.000°C	0000,0000	000X,XXXX
- 1.125°C	1111,1110	111X,XXXX
- 2.250°C	1111,1101	110X,XXXX
- 25.750°C	1110,0110	010X,XXXX
- 127.875°C	1000,0000	001X,XXXX

6.5 ALERT# Output

The NCT7509 ALERT# pin is an active-low open-drain output pin which is triggered when measured temperature exceeds the limitation defined in the limit registers. There are three types of ALERT#

output mode: the ALERT# output comparator mode, the ALERT# output interrupt mode, and the ALERT# output SMBus™ ALERT# mode.

6.5.1 ALERT# Output Comparator Mode

Figure 1 shows the mechanism of the ALERT# output comparator mode. In this mode, the ALERT# pin will be alerted if the monitored temperature is out-of-limit and the ALERT# pin keeps low until the temperature goes back to the target range.

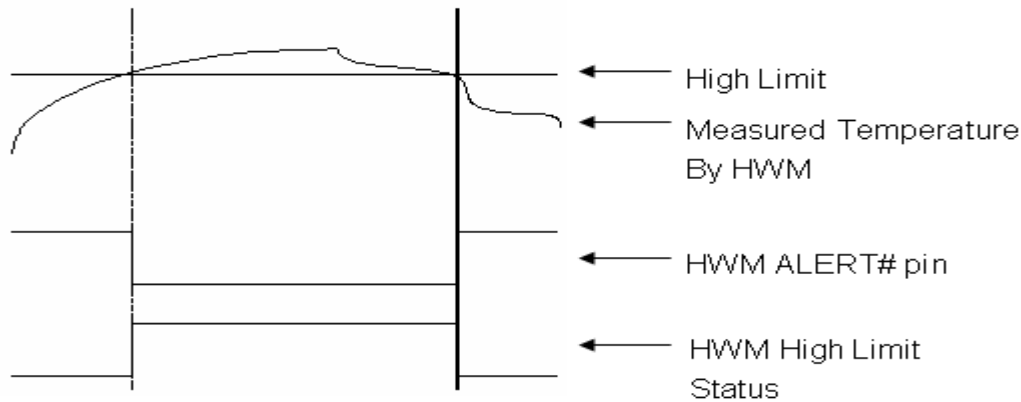


Figure 1

6.5.2 ALERT# Output Interrupt Mode

Figure 2 shows the mechanism of the ALERT# output interrupt mode. In this mode, the NCT7509 will set the ALERT mask bit of Configuration Register during a read of the Status Register if any flag in Status Register, except the ADC_Busy flag and Remote Diode Open flag, is set. This prevents further ALERT# triggering until the master has reset the ALERT mask bit (write 0 to Alert_MSK), at the end of the interrupt service routine. The Status Register flags are cleared only upon a read Status Register command from the master and will be re-alerted at the end of the next temperature conversion if the measured temperature still falls outside of the allowed range.

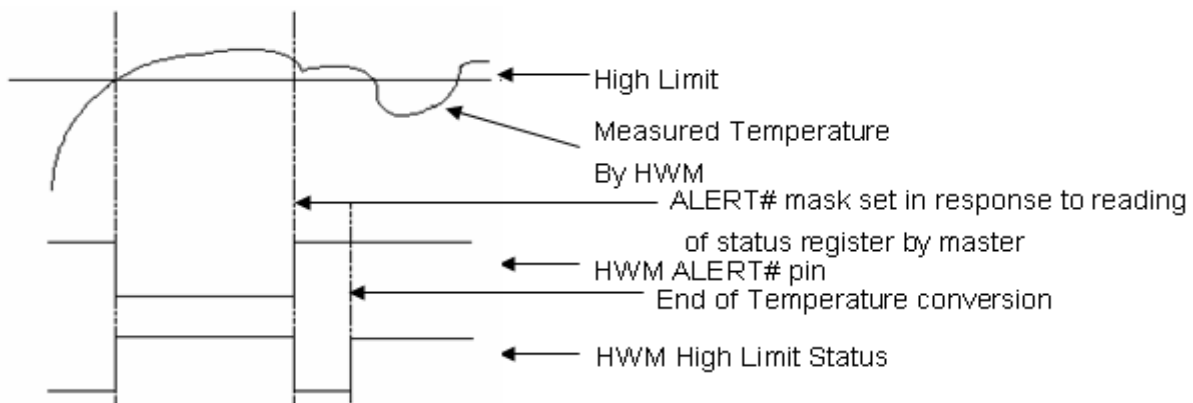


Figure 2

6.5.3 ALERT# Output SMBus™ alert Mode

Figure 3 shows the mechanism of the ALERT# output SMBus™ alert mode. In this mode, the ALERT# output of the NCT7509 is connected to the SMBus™ alert line which has more than one device connected to it. Through such an implementation, SMBus™ alert mode can assist the master in resolving which slave generates an interrupt. When the measured temperature falls outside of the allowed range, the ALERT# pin will be pulled low and the corresponding alert flags in Status Register will be set to 1. The ALERT mask bit will just be set if there is a read command for Status Register or when SMBus™ ALERT Response Address (ARA) occurs from master (Alert Response Address is 0001100x). Meanwhile, the NCT7509 will generate and return its own address to the master. If the temperature never falls outside of the allowed range, the latched ALERT# pin can release by the reset ALERT mask bit and the latched corresponding alert flags in Status Register can release by reading command for Status Register.

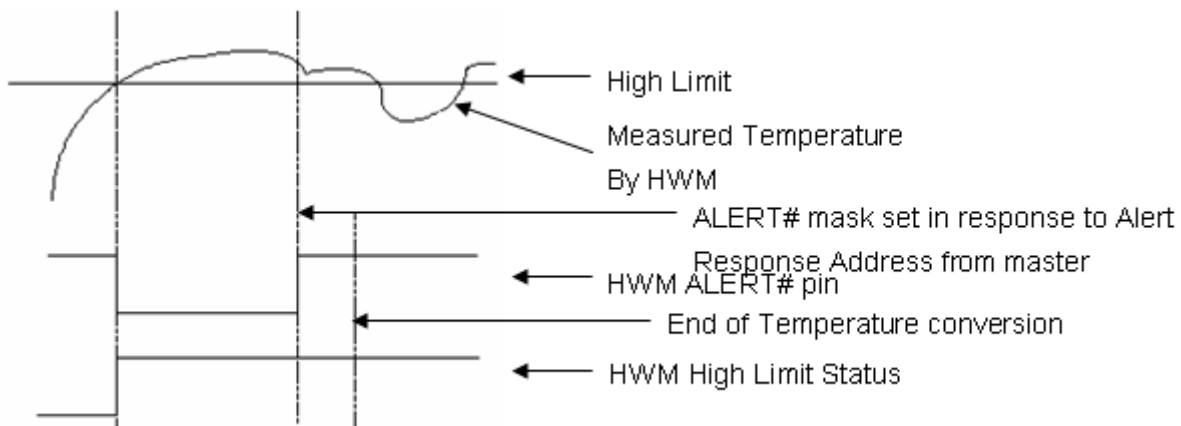


Figure 3

6.6 T_CRIT# Output

T_CRIT# output pulls low when the measured temperature exceeds the critical temperature setting. Once the T_CRIT# output pulls low, it will not be set high until the measured temperature is lower than "T_CRIT - TH", where TH is Temperature Hysteresis. Status Register will not be reset until it is read and the temperature conversion falls below the T_CRIT set point, the ALERT-MSK bit of Configuration Register will be set after Status Register read. Figure 4 shows this mechanism.

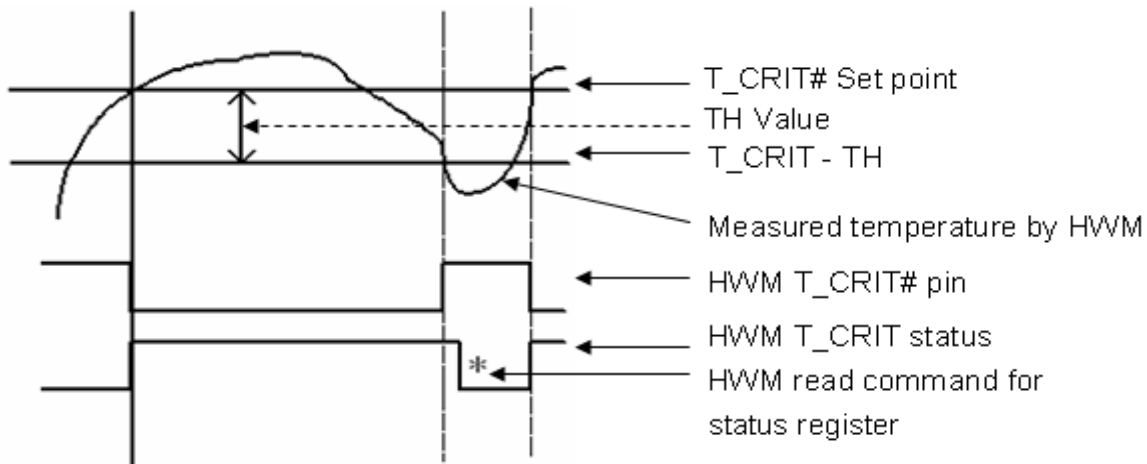


Figure 4

6.7 FAN_IN Count Calculation

The FAN_IN tachometer high byte and low byte are combined to 12-bitCountValue. Real RPM (Rotate per Minute) calculation should follow the formula:

$$FanSpeed(RPM) = \frac{1.35 \times 10^6}{(12 - bitCountValue) \times (FanPoles / 4)}$$

In this formula, FanPoles stands for the number of NS pole pairs inside the fan. Normally an N-S-N-S Fan (FanPoles=4) generates 2 pulses after completing one rotation.

6.8 FAN_OUT Duty Cycle Calculation

The NCT7509 provides 1 set of PWM for fan speed control. The duty cycle of PWM can be programmed by an 8-bit register. The expression of duty cycle can be represented as follow formula:

$$Duty - cycle(\%) = \frac{\text{Programmed 8-bit Register Value}}{255} \times 100\%$$

6.9 SMART FAN™ IV Control Parameters

In SMART FAN™ IV Mode, there are some Fan control parameters as below descriptions:

6.9.1 Step Up Time / Step Down Time

SMART FAN™ IV is designed for the smooth operation of the fan. The Up Time / Down Time register defines the time interval between successive duty increases or decreases. If this value is set too small, the fan will not have enough time to speed up after tuning the duty and sometimes may result in unstable fan speed. On the other hand, if Up Time / Down Time is set too large, the fan may not work fast enough to dissipate the heat. This register should never be set to 0, otherwise, the fan duty will be abnormal.

6.9.2 Fan Output Start-up Value

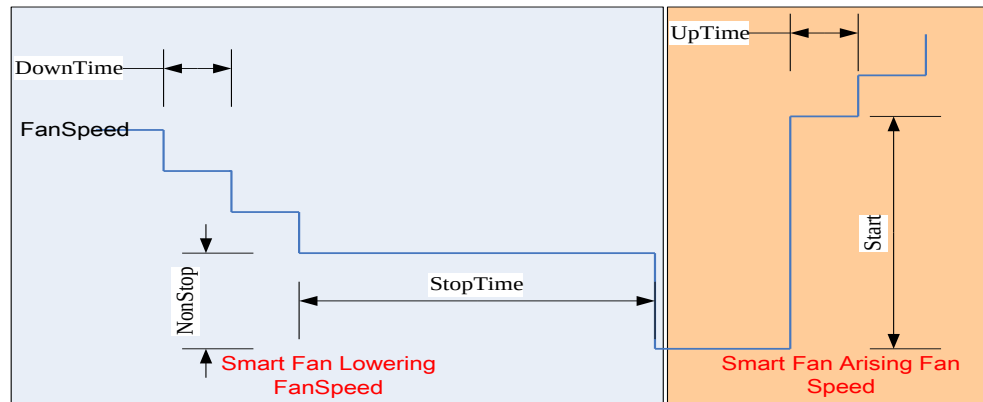
From still to rotate, the fan usually needs a higher fan output value to generate enough torque to conquer the restriction force. Thus the Fan Output Start-up Value is used to turn on the fan with the specified output value.

6.9.3 Fan Output Nonstop Value

It takes some time to bring a fan from still to working state. Therefore, Nonstop value are designed with a minimum fan output to keep the fan working when the system does not require the fan to help reduce heat but still want to keep the fast response time to speed up the fan.

6.9.4 Fan Output Stop Time

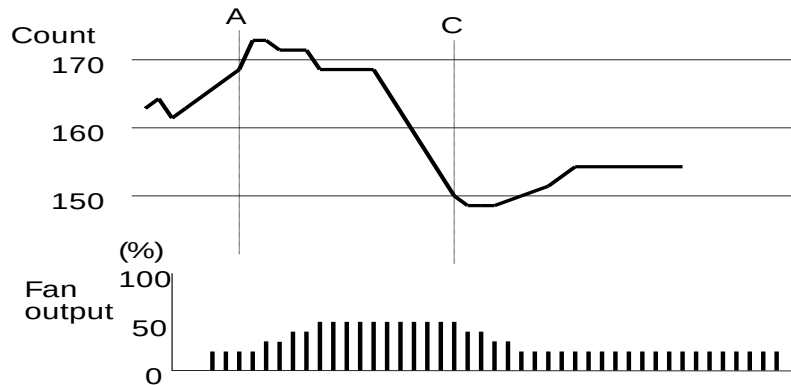
A time interval is specified to turn off the fan if SMART FAN™ IV continuously requests to slow down the fan which has already reached the Stop time.



Smart Fan Control Parameters Figure

6.10 Speed Cruise Mode

Fan Speed Cruise mode keeps the fan speed in a specified range. This range is defined by a fan speed count and an interval (e.g., 160 ± 10). As long as the fan speed count is in the specified range, fan output remains the same. If the fan speed count is higher than the high end (e.g., 170), fan output increases to make the count lower. If the fan speed count is lower than the low end (e.g., 150), fan output decreases to make the count higher. One example is illustrated in this figure.



Mechanism of Fan Speed Cruise™ Mode

6.11 Thermal Cruise Mode

Thermal Cruise mode is an algorithm to control the fan speed to keep the temperature source around the Target Temperature of Temperature Inputs. If the temperature source detects temperatures higher or lower than the target temperatures with Hysteresis of Temperature, Smart Fan Control will take actions to speed up or slow down the fan to keep the temperature within the tolerance range.

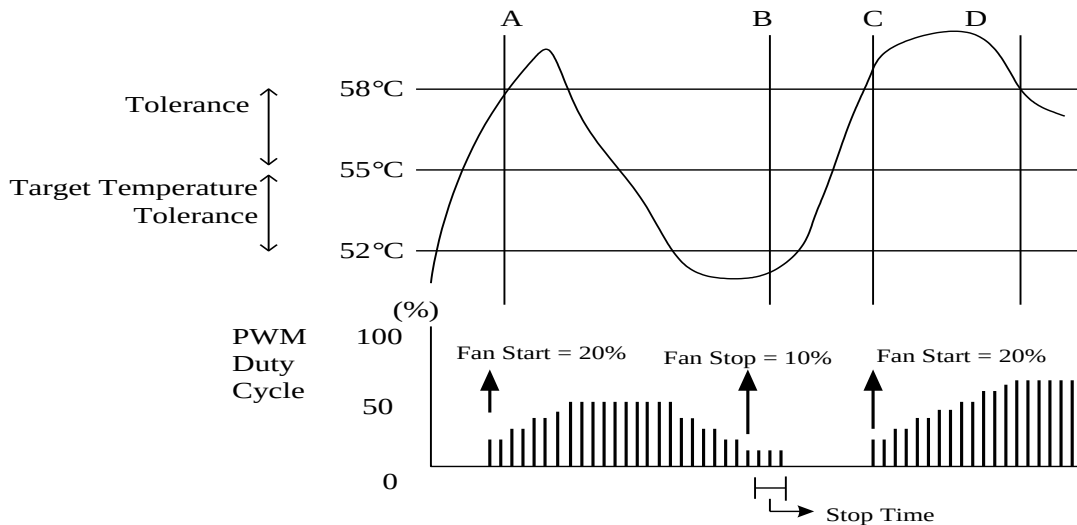
Thermal Cruise mode controls the fan speed to keep the temperature in a specified range. This range is defined by a temperature and the interval (e.g., $55^{\circ}\text{C} \pm 3^{\circ}\text{C}$). As long as the current temperature remains below the low end of this range (i.e., 52°C), the fan is off. Once the temperature exceeds the low end, the fan turns on at a start up speed defined (e.g., 20% output). Thermal Cruise mode then controls the fan output according to the current temperature. Three conditions may occur:

- (1) If the temperature still exceeds the high end, fan output increases slowly. If the fan is operating at full speed but the temperature still exceeds the high end, a warning message is issued to protect the system.
- (2) If the temperature falls below the high end (e.g., 58°C) but remains above the low end (e.g., 52°C), fan output remains the same.
- (3) If the temperature falls below the low end (e.g., 52°C), fan output decreases slowly to zero or to a specified "Nonstop value". This nonstop value is specified in **Address 5A_{HEX}**. The fan remains at the nonstop value for the period of time defined in **Address 5B_{HEX}**.

In general, Thermal Cruise mode means

- if the current temperature is higher than the high end, increase the fan speed;
- if the current temperature is lower than the low end, decrease the fan speed;
- otherwise, keep the fan speed the same.

The following figures illustrate two examples of Thermal Cruise mode.



Mechanism of Thermal Cruise™ Mode (PWM Duty Cycle)

6.12 SMART FAN™ IV & Close Loop Fan Control Mode

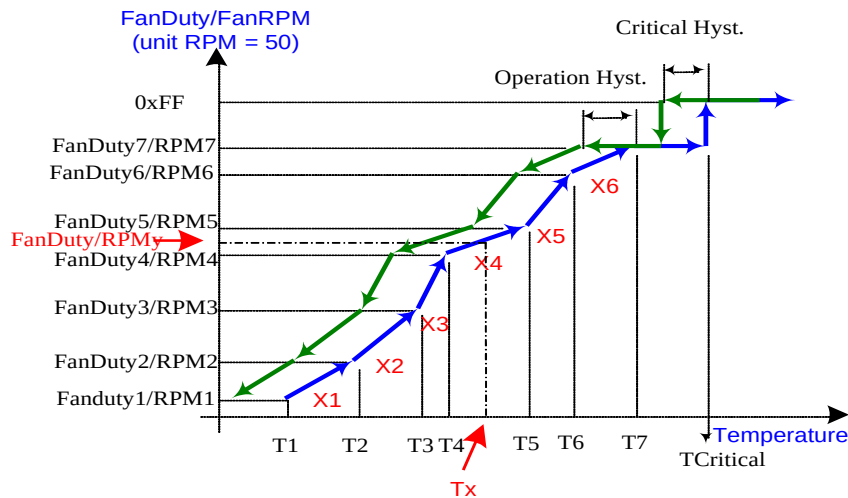
SMART FAN™ IV and Close Loop Fan Control Mode offer 6 slopes to control the fan speed.

The 6 slopes can be obtained by setting FanDuty/RPM1~FanDuty/RPM7 and T1~T7 through the registers. When the temperature rises, FAN Output will calculate the target FanDuty/RPM based on the current slope. For example, assuming Tx is the current temperature and FanDuty/RPMy is the target, then the slope:

$$X4 = \frac{(\text{FanDuty5/RPM5}) - (\text{FanDuty4/RPM4})}{(T5 - T4)}$$

Fan Output:

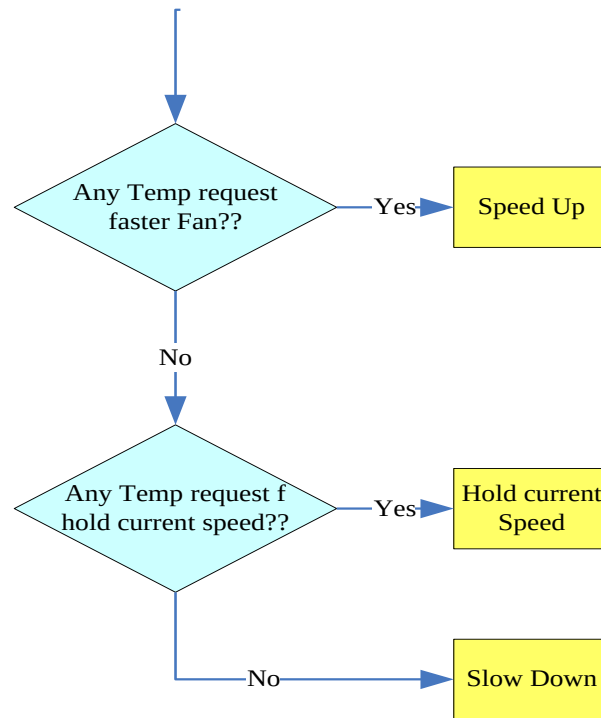
$$\text{Target FanDuty or RPM} = (\text{FanDuty4 or RPM4}) + (Tx - T4) \cdot X4$$



SMART FAN™ IV & Close Loop Fan Control Mechanism

In addition, SMART FAN™ IV & Close Loop Fan Control can also set up Critical Temperature and Hysteresis. If the current temperature exceeds Critical Temperature, external fan will be forced by maximum FanDuty to meet the largest target FanDuty or RPM, Which is 0xFF. The target FanDuty & RPM value will be determined in accordance to the slope only when the temperature falls below (TCritical – Criticl Hyst.)

NCT7509 provide 2 temperature source selects to map the fan, the algorithm will make a decision to control the fan as below figure:

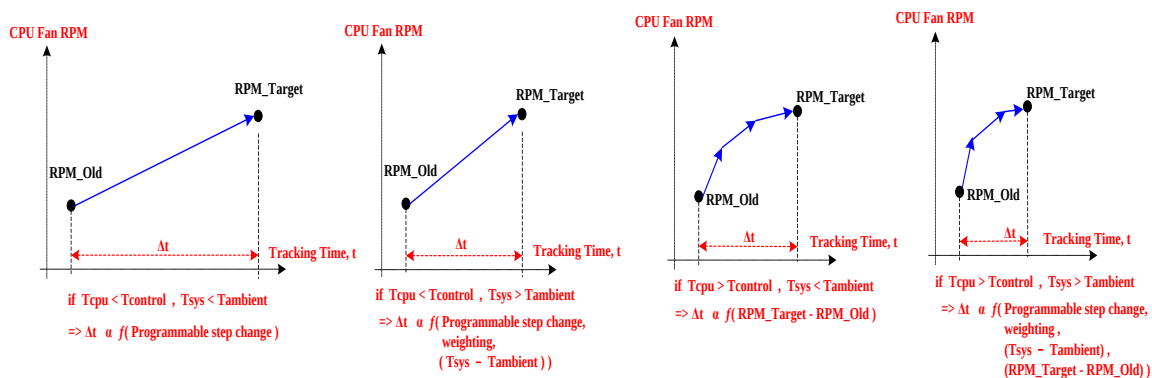


6.13 Dynamic Fast Tracking Feature

In the SMART FAN™ IV & Close Loop Control Mode, in order to have a faster Fan Duty update response to external temperature variation, NCT7509 involves a Dynamic Fast Tracking mode. That how fast could be reached is depended on user's configuration and how rapid temperature variation.

In addition to independent temperature control method, which means that one external fan would be controlled by only one temperature source, NCT7509 also support combined temperature control method. User could conjugate CPU & System temperature with CPU fan to obtain a better thermal management on the system level through this feature.

Per appropriate configuration, fan control response time could come out following behavior.



In this demonstration, CPU & System temperature will link to CPU fan response.

7. REGISTER SUMMARY

7.1 Register Map

Idx	Register Name	Attr	Dft	7	6	5	4	3	2	1	0
0	LDT Readout	RO	00	MNTREG_LT[7:0]							
1	RT1 Temp MSB	RO	00	MNTREG_RT1[10:3]							
2	Alert Status	RO	00	ADC_Busy	STS_LTHA	Reserved	STS_RT1HA	STS_RT1LA	STS_RT10	STS_RT1C	STS_TACH
3	Configuration [R]	RW	15	ALERT_MSK	STOP_Mnt	DIS_FANOUT	EN_FANIN	Reserved	EN_RT1	EN_WTC	EN_FaultQueue
4	Conversion Rate [R]	RW	08	Reserved				ConvRate[3:0]			
5	LT Alert Temp [R]	RW	46	LT_HAT[7:0]							
6	Reserved			Reserved							
7	RT1 High Alert Temp MSB [R]	RW	46	RT1_HAT[10:3]							
8	RT1 Low Alert Temp MSB [R]	RW	D8	RT1_LAT[10:3]							
9	Configuration [W]	RW	15	ALERT_MSK	STOP_Mnt	DIS_FANOUT	EN_FANIN	Reserved	EN_RT1	EN_WTC	EN_FaultQueue
A	Conversion Rate [W]	RW	08	Reserved				ConvRate[3:0]			
B	LT Alert Temp [W]	RW	46	LT_HAT[7:0]							
C	Reserved			Reserved							
D	RT1 High Alert Temp MSB [W]	RW	46	RT1_HAT[10:3]							
E	RT1 Low Alert Temp MSB [W]	RW	D8	RT1_LAT[10:3]							
F	One Shot Conversion	WO	FF								
10	RT1 Temp LSB	RO	00	MNTREG_RT1[2:0]				Reserved			
11	RT1 Offset Temp MSB	RW	00	OFFSET_RT1[10:3]							
12	RT1 Offset Temp LSB	RW	00	OFFSET_RT1[2:0]				Reserved			
13	RT1 High Alert Temp LSB	RW	00	RT1_HAT[2:0]				Reserved			
14	RT1 Low Alert Temp LSB	RW	00	RT1_LAT[2:0]				Reserved			
16	Alert Mask	RW	06	MSK_LTH	Reserved	MSK_RT1H	MSK_RT1L	Reserved	MSK_RT1C	MSK_TACH	
19	RT1 Critical Temp	RW	--	RT1_CT[7:0]							
20	Reserved			Reserved							
21	Critical Temp Hysteresis	RW	0A	Reserved				CTH[4:0]			
2D	Customer Data Log Register 1	RW	00	CustomerLogReg1[7:0]							
2E	Customer Data Log Register 2	RW	00	CustomerLogReg2[7:0]							
2F	Customer Data Log Register 3	RW	00	CustomerLogReg3[7:0]							
40	FAN Count Readout MSB	RO	00	FANIN[11:4]							
41	FAN Count Readout LSB	RO	00	FANIN[3:0]				Reserved			
42	FAN Count High	RW	FF	FANIN_HL[11:4]							

Idx	Register Name	Attr	Dft	7	6	5	4	3	2	1	0	
	Limit MSB											
43	FAN Count High Limit LSB	RW	E0	FANIN_HL[3:0]				Reserved				
44	FanctrlDutyCycle	RW	80	FANDuty								
45	Configuration Register 1	RW	00	Share_Sour_Temp2		Share_Sour_Temp1		EN_ShareMode		EN_SpeedCruise		
46	Configuration Register 2	RW	10	Reserved		Temp2FanSelect		Temp1FanSelect		FanControlMode		
47	Configuration Register 3	RW	A1	PWMPOL		Reserved		Temp2_Sour_Sel		Temp1_Sour_Sel		
48	Configuration Register 4	RW	00	Reserved				TwoDimension		SimpleMode		FastTracking
49	Dynamic feature Register 1	RW	50	Tcontrol								
4A	Dynamic feature Register 2	RW	3C	Tbound								
4B	Dynamic feature Register 3	RW	35	DownFan_Tol_FanDuty			Weight_SYS			Reserved		
4C	Dynamic feature Register 4	RW	52	Unstable_Depth			StepCng_Up			StepCng_Down		
4D	Dynamic feature Register 5	RW	02	FCount_FDuty_Weight_High (Twodimension = 1)				FCount_FDuty_Step_High (Twodimension = 1)				
4E	Dynamic feature Register 6	RW	02	FCount_FDuty_Weight_Mid (Twodimension = 1)				FCount_FDuty_Step_Mid (Twodimension = 1)				
4F	Dynamic feature Register 7	RW	04	FCount_FDuty_Weight_Low (Twodimension = 1)				FCount_FDuty_Step_Low (Twodimension = 1)				
50	Dynamic feature Register 8	RW	0A	Generic_Tol_FanInCount								
51	Dynamic feature Register 9	RW	99	RPM_Boundary_High[7:0]								
52	Dynamic feature Register 10	RW	1C	RPM_Boundary_Low[7:0]								
53	Dynamic feature Register 11	RW	12	RPM_Boundary_High[11:8]				RPM_Boundary_Low[11:8]				
54	Dynamic feature Register 12	RW	05	DownFan_Tol_FanInCount_High[7:0]								
55	Dynamic feature Register 13	RW	0A	DownFan_Tol_FanInCount_Low[7:0]								
56	Fanctl Step Up Time	RW	0A	UpTime								
57	Fanctl Step Down Time	RW	0A	DownTime								
58	PWM1 Prescalar	RW	84	CKSEL				FanOutDivisor[6:0]				
59	Fanctl Start Duty Cycle	RW	30	StartDutyCycle								
5A	Fanctl Nonstop Duty Cycle	RW	10	NonStopDutyCycle								
5B	Stop Time of Fanctl	RW	FF	StopTime								
5C	FANIN Target speed (HB)	RW	60	TargetFanInCount[11:4]								
5D	FANIN Target speed (LB)	RW	00	TargetFanInCount[3:0]				Reserved				
5E	Target Speed Tolerance	RW	10	Reserved				TOL_FanInCount[5:0]				
5F	Temp1 Target Temperature	RW	46	TargetTemp1								
60	Temp2 Target Temperature	RW	46	TargetTemp2								
61	Temp1 Hysteresis	RW	2B	Reserved			Criti_HysT1			Oper_HysT1		
62	Temp2 Hysteresis	RW	2B	Reserved			Criti_HysT2			Oper_HysT2		

Idx	Register Name	Attr	Dft	7	6	5	4	3	2	1	0
63	Table 1 Transition Point 1	RW	0A	Temp1Table_TR1							
64	Table 1 Transition Point 2	RW	14	Temp1Table_TR2							
65	Table 1 Transition Point 3	RW	1E	Temp1Table_TR3							
66	Table 1 Transition Point 4	RW	28	Temp1Table_TR4							
67	Table 1 Transition Point 5	RW	32	Temp1Table_TR5							
68	Table 1 Transition Point 6	RW	3C	Temp1Table_TR6							
69	Table 1 Transition Point 7	RW	55	Temp1Table_TR7							
6A	Table 1 Critical Point	RW	5A	Temp1Table_TRCritical							
6B	Table 1 Y-axis Transition Point 1	RW	28	Temp1Table_FL1							
6C	Table 1 Y-axis Transition Point 2	RW	50	Temp1Table_FL2							
6D	Table 1 Y-axis Transition Point 3	RW	78	Temp1Table_FL3							
6E	Table 1 Y-axis Transition Point 4	RW	96	Temp1Table_FL4							
6F	Table 1 Y-axis Transition Point 5	RW	B4	Temp1Table_FL5							
70	Table 1 Y-axis Transition Point 6	RW	D2	Temp1Table_FL6							
71	Table 1 Y-axis Transition Point 7	RW	F0	Temp1Table_FL7							
72	Table 2 Transition Point 1	RW	19	Temp2Table_TR1							
73	Table 2 Transition Point 2	RW	1E	Temp2Table_TR2							
74	Table 2 Transition Point 3	RW	23	Temp2Table_TR3							
75	Table 2 Transition Point 4	RW	28	Temp2Table_TR4							
76	Table 2 Transition Point 5	RW	2D	Temp2Table_TR5							
77	Table 2 Transition Point 6	RW	32	Temp2Table_TR6							
78	Table 2 Transition Point 7	RW	37	Temp2Table_TR7							
79	Table 2 Critical Point	RW	3C	Temp2Table_TRCritical							
7A	Table 2 Y-axis Transition Point 1	RW	28	Temp2Table_FL1							
7B	Table 2 Y-axis Transition Point 2	RW	50	Temp2Table_FL2							
7C	Table 2 Y-axis Transition Point 3	RW	78	Temp2Table_FL3							
7D	Table 2 Y-axis Transition Point 4	RW	96	Temp2Table_FL4							
7E	Table 2 Y-axis Transition Point 5	RW	B4	Temp2Table_FL5							
7F	Table 2 Y-axis Transition Point 6	RW	D2	Temp2Table_FL6							
80	Table 2 Y-axis Transition Point 7	RW	F0	Temp2Table_FL7							
BF	RT Filter & Alert mode	RW	00	Reserved			RT1F			Alert_MD	
FD	CID (Chip ID)	RO	50	50h							

Idx	Register Name	Attr	Dft	7	6	5	4	3	2	1	0
FE	VID (Vendor ID)	RO	50	50h							
FF	DID (Device ID)	RO	9x	9xH (x=0,1,2...)							

7.2 Register Detail

7.2.1 Local Diode Temperature Readout Register

Location : Address 00h

Type : Read Only

Power on default value : 00

BITS	7	6	5	4	3	2	1	0
Name	Local Diode Temperature Readout Value. The real temperature value calculation is referred to TEMPERATURE MEASUREMENT DATA FORMAT.							
Value	SIGN	64	32	16	8	4	2	1

7.2.2 Remote Diode 1 Temperature Readout (MSB) Register

Location : Address 01h

Type : Read Only

Power on default value : 00

BITS	7	6	5	4	3	2	1	0
Name	Remote Diode 1 Temperature Readout Value. The real temperature value calculation is referred to TEMPERATURE MEASUREMENT DATA FORMAT.							
Value	SIGN	64	32	16	8	4	2	1

7.2.3 Alert Status Register

Location : Address 02h

Type : Read Only

Power on default value : 00

BITS	7	6	5	4	3	2	1	0
Name	ADC_Busy	STS_LTHA	Reserved	STS_RT1HA	STS_RT1LA	STS_RT1O	STS_RT1C	STS_TACH
Default	0	0		0	0	0	0	0

BITS	FLAG NAME	DESCRIPTION
7	ADC_Busy	If set to '1' indicates ADC is busy converting.
6	STS_LTHA	If set to '1' indicates a measured Local Diode Temperature Higher than Local High set point (High Limit).
5	Reserved	
4	STS_RT1HA	If set to '1' indicates a measured Remote Diode1 Temperature higher than Remote High set point (High Limit).

BIT	FLAG NAME	DESCRIPTION
3	STS_RT1LA	If set to '1' indicates a measured Remote Diode1 Temperature lower than Remote Low set point (Low Limit).
2	STS_RT1O	If set to '1' indicates a Remote Diode1 disconnect.
1	STS_RT1C	If set to '1' indicates a Remote Diode1 Critical Temperature alarm.
0	STS_TACH	If set to '1' indicates Tachometer count is higher than Tachometer Limit.

7.2.4 Configuration Register

Location : Address 03h and 09h

Type : Read/Write

Power on default value : 15

BIT	7	6	5	4	3	2	1	0
Name	ALERT_MSK	STOP_Mnt	DIS_FANOUT	EN_FANIN	RESERVED	EN_RT1	EN_WTC	EN_FaultQueue
Default	0	0	0	1		1	0	1

BIT	DESCRIPTION
7	ALERT_MSK – ALERT# function is enable 0 = Enable 1 = Disable
6	STOP_Mnt – Stop Monitor and entry Standby 0 = Monitor 1 = Stop Monitor
5	DIS_FANOUT – Disable PWM FANOUT. 0 = Enable PWM FANOUT 1 = Disable PWM FANOUT
4	EN_FANIN – Enable FANIN monitoring. 0 = Disable 1 = Enable
2	EN_RT1 – Enable Remote Diode 1 monitoring. 0 = Disable 1 = Enable
1	EN_WTC – Enable Override POR Value of Critical Temperature 0 = Disable 1 = Enable
0	EN_FaultQueue – Enable Fault Queue function 0 = Disable. ALERT# and T_CRIT# will be generated if monitor result of any channel is above or below high/low setting point. 1 = Enable. ALERT# and T_CRIT# will be generated if monitor result of any channel is

BIT	DESCRIPTION
	consecuete three times above or below high/low setting point.

7.2.5 Conversion Rate Register

Location : Address 04h and 0Ah

Type : Read/Write

Power on default value : 08

BIT	7	6	5	4	3	2	1	0
Name	Reserved				ConvRate			
Default					1	0	0	0

BIT<D7:D0>	FREQUENCY/TIME
00h	0.0625Hz / 16sec
01h	0.125Hz / 8sec
02h	0.25Hz / 4sec
03h	0.5Hz / 2sec
04h	1Hz / 1sec
05h	2Hz / 0.5sec
06h	4Hz / 0.25sec
07h	8Hz / 0.125sec
08h	16Hz / 0.0625sec
09h-FFh	Reserved

7.2.6 Local Diode Temperature Alert Temperature Register

Location : Address 05h and 0Bh

Type : Read/Write

Power on default value : 46

BIT	7	6	5	4	3	2	1	0
Name	LDT Alert Temperature							
Value	SIGN	64	32	16	8	4	2	1
Default	46 _{HEX} (70°C)							

7.2.7 Remote Diode 1 Temperature High Alert Temperature (MSB) Register

Location : Address 07h and 0Dh

Type : Read/Write

Power on default value : 46

BIT	7	6	5	4	3	2	1	0
Name	RT1 High Alert Temperature High Byte							



Value	SIGN	64	32	16	8	4	2	1
Default	46 _{HEX} (70°C)							

7.2.8 Remote Diode 1 Temperature Low Alert Temperature (MSB) Register

Location : Address 08h and 0Eh

Type : Read/Write

Power on default value : D8

BIT	7	6	5	4	3	2	1	0
Name	RT1 Low Alert Temperature High Byte							
Value	SIGN	64	32	16	8	4	2	1
Default	D8 _{HEX} (-40°C)							

7.2.9 One Shot Conversion Register

Location : Address 0Fh

Type : Write Only

BIT	DESCRIPTION
7-0	One Shot Conversion – When enter Stop Monitor state, to fill any value into this register will trigger one temperature conversion cycle.

7.2.10 Remote Diode 1 Temperature Readout (LSB) Register

Location : Address 10h

Type : Read Only

Power on default value : 00

BIT	7	6	5	4	3	2	1	0
Name	Remote Diode 1 Temperature Readout Value. The real temperature value calculation is referred to TEMPERATURE MEASUREMENT DATA FORMAT.			Reserved				
Value	0.5	0.25	0.125	0				

7.2.11 Remote Diode 1 Temperature Offset Register (MSB) Register

Location : Address 11h

Type : Read/Write

Power on default value : 00

BIT	7	6	5	4	3	2	1	0
Name	RT1 OFFSET VALEU High Byte							
Value	SIGN	64	32	16	8	4	2	1
Default	00 _{HEX}							



7.2.12 Remote Diode 1 Temperature Offset Register (LSB) Register

Location : Address 12h

Type : Read/Write

Power on default value : 00

BIT	7	6	5	4	3	2	1	0
Name	RT1 OFFSET VALUE Low Byte							
Value	0.5	0.25	0.125					
Default	00 _{HEX}							

7.2.13 Remote Diode 1 Temperature High Alert Temperature (LSB) Register

Location : Address 13h

Type : Read/Write

Power on default value : 00

BIT	7	6	5	4	3	2	1	0
Name	RT1 High Alert Temperature Low Byte							
Value	0.5	0.25	0.125					
Default	00 _{HEX}							

7.2.14 Remote Diode 1 Temperature Low Alert Temperature (LSB) Register

Location : Address 14h

Type : Read/Write

Power on default value : 00

BIT	7	6	5	4	3	2	1	0
Name	RT1 Low Alert Temperature Low Byte							
Value	0.5	0.25	0.125					
Default	00 _{HEX}							

7.2.15 Alert Mask Register

Location : Address 16h

Type : Read/Write

Power on default value : 06

BIT	7	6	5	4	3	2	1	0
Name	MSK_LTH	Reserved		MSK_RT1H	MSK_RT1L	Reserved	MSK_RT1C	MSK_TACH
Default	0			0	0		1	0

BIT	DESCRIPTION
7	MSK_LTH – Local Diode Temperature High Alert Mask 0 = Alert is not masked

BIT	DESCRIPTION
	1 = Alert is masked
4	MSK_RT1H– Remote Diode 1 Temperature High Alert Mask 0 = Alert is not masked 1 = Alert is masked
3	MSK_RT1L– Remote Diode 1 Temperature Low Alert Mask 0 = Alert is not masked 1 = Alert is masked
1	MSK_RT1C– Remote Diode 1 Temperature Critical Mask 0 = Alert is not masked 1 = Alert is masked
0	MSK_TACH– Fan Tachometer Alert Mask 0 = Alert is not masked 1 = Alert is masked

7.2.16 Remote Diode 1 Critical Temperature Register

Location : Address 19h

Type : Read/Write

Power on default value : Power on trapping after power up 100ms

BIT	7	6	5	4	3	2	1	0
Name	RT1 Critical Temperature The format of Temperature is 8-bit 2's complement and the range is -128°C ~ 127°C .							
Value	SIGN	64	32	16	8	4	2	1
Default	Hardware Strapping							

The default value is trapping after power up 100ms by different pull-up resistors of ALERT# pin :

PULL-UP RESISTOR		TEMPERATURE ($^{\circ}\text{C}$)
ALERT#	2K Ω	75
	7.5K Ω	90
	10.5K Ω	100
	14K Ω	105
	18.7K Ω	110

7.2.17 Critical Temperature Hysteresis Register

Location : Address 21h

Type : Read/Write

Power on default value : 0A

BIT	7	6	5	4	3	2	1	0
Name	Critical Temperature Hysteresis The format of Temperature is 5-bit integer and the range is 0°C~31°C.							
Value				16	8	4	2	1
Default	0A _{HEX} (10°C)							

7.2.18 Customer Data Log Registers

Location : Address 2Dh 2Eh 2Fh

Type : Read/Write

Power on default value : 00

BIT	7	6	5	4	3	2	1	0
Name	Customer Data Log Register							
Default	00 _{HEX}							

7.2.19 Fan Count Readout (MSB) Register

Location : Address 40h

Type : Read Only

Power on default value : 00

BIT	7	6	5	4	3	2	1	0
Name	FANIN tachometer readout high byte. The real FANIN RPM value calculation is referred to FANIN COUNT CACLULATION description. 12-bitCount Value bit[11:4]							

7.2.20 Fan Count Readout (LSB) Register

Location : Address 41h

Type : Read Only

Power on default value : 00

BIT	7	6	5	4	3	2	1	0
Name	FANIN tachometer readout low byte 12-bitCount Value bit [3:0]				Reserved.			

7.2.21 Fan Count High Limit (MSB) Register

Location : Address 42h

Type : Read/Write

Power on default value : FF

BIT	7	6	5	4	3	2	1	0
Name	FANIN_HL FANIN tachometer count limit (high byte). The real FANIN RPM count limit value calculation is referred to FANIN COUNT CACLULATION description. 12-bitCount Value bit[11:4]							
Default	FF _{HEX}							

7.2.22 Fan Count High Limit (LSB) Register

Location : Address 43h

Type : Read/Write

Power on default value : EE

BIT	7	6	5	4	3	2	1	0
Name	FANIN_HL_LSB				Reversed			
	FANIN tachometer count limit (lowe byte). 12-bitCount Value bit [3:0]							
Default	EE _{HEX}							

7.2.23 Fanctrl Duty Cycle Register

Location : Address 44h

Type : Read / Write (in Manual Mode)

Read Only (in the Smart Fan mode)

Power on default value : 80

BIT	7	6	5	4	3	2	1	0
Name	FANDuty							
Default	80 _{HEX}							

BIT	DESCRIPTION
7-0	FANDuty – Current Fanctrl output value. In Manual Mode, programming this register to set desired PWM duty cycle. In Thermal Cruise or SMART FAN™ IV algorithm, this register reveals the current PWM duty cycle and is Read Only.

7.2.24 Generic Fan Control Configuration Register 1 (GFCCR1) Register

Location : Address 45h

Type : Read/Write

Power on default value : 00

BIT	7	6	5	4	3	2	1	0
Name	Share_Sour_Temp2			Share_Sour_Temp1			EN_ShareMode	EN_SpeedCruise
Default	00 _{HEX}							

BIT	DESCRIPTION
7-5	Share_Sour_Temp2 : Select which temperature source could share control table in SMART FAN™ IV mode 001 : Local temperature will be referred to SMART FAN™ IV control table 2 010 : Remote 1 temperature will be referred to SMART FAN™ IV control table 2 Others : Reserved
4-2	Share_Sour_Temp1 : Select which temperature source could share control table in SMART FAN™ IV mode 001 : Local temperature will be referred to SMART FAN™ IV control table 1 010 : Remote 1 temperature will be referred to SMART FAN™ IV control table 1 Others : Reserved
1	EN_ShareMode : Enable sharing table function in SMART FAN™ IV control mode 0 = Disable 1 = Enable
0	EN_SpeedCruise : Apply Speed Cruise™ mode to FANCTL 0 = Fan control mode is decide by GFCCR2 register. (Default) 1 = FANCTL is applies to Speed Cruise™ control for FANIN speed input.

7.2.25 Generic Fan Control Configuration Register 2 (GFCCR2) Register

Location : Address 46h

Type : Read/Write

Power on default value : 10

BIT	7	6	5	4	3	2	1	0
Name	Reserved				Temp2FanSelect	Temp1FanSelect	FanControlMode	
Default	10 _{HEX}							

BIT	DESCRIPTION
7-4	Reserved.

BIT	DESCRIPTION
3	Temp2 FanSelect : Decide temp2 whether effect FANCTRL or not. 0 = Independent 1 = Dependent
2	Temp1 FanSelect : Decide temp1 whether effect FANCTRL or not. 0 = Independent 1 = Dependent
1-0	FanControlMode : From temperature view, decide Fan Control mode 00 : Temp2 & Temp1 practice thermal cruise algorithm 01: Temp2 practices thermal cruise algorithm and Temp1 is SMART FAN™ IV algorithm Others : Reserved

7.2.26 Generic Fan Control Configuration Register 3 (GFCCR3) Register

Location : Address 47h

Type : Read/Write

Power on default value : A1

BIT	7	6	5	4	3	2	1	0
Name	PWMPOL	Reserved	Temp2_Sour_Sel			Temp1_Sour_Sel		
Default	A1 _{HEX}							

BIT	DESCRIPTION
7	PWMPOL : Control FANCTL PWM output polarity. 0 = Low active. PWM is controlled by negative duty cycle. 1 = High active. (Default). PWM is controlled by positive duty cycle.
6	Reserved
5-3	Temp2_Sour_Sel : Temperature source selection for Table2 in SMART FAN™ IV algorithm 001 = Local temperature 010 = Remote temperature 1 Others : Reserved
2-0	Temp1_Sour_Sel : Temperature source selection for Table1 in SMART FAN™ IV algorithm 001 = Local temperature 010 = Remote temperature 1 Others : Reserved

7.2.27 Generic Fan Control Configuration Register 4 (GFCCR4) Register

Location : Address 48h

Type : Read/Write

Power on default value : 00

BIT	7	6	5	4	3	2	1	0
Name	Reserved					TwoDimension	SimpleMode	FastTracking
Default	00 _{HEX}							

BIT	DESCRIPTION
7-3	Reserved
2	TwoDimension : Close-Loop Fan Control mode (RPM to Temperature) enabling 1 = RPM to Temperature control 0 = FanDuty to Temperature control
1	SimpleMode : Select the type of Fan Duty change rate. It's available only with Fast Tracking = 1. 0 : Fan Duty change rate is dynamic 1 : Fan Duty change rate is programmable. Set by StepCng_Up & StepCng_Down
0	FastTracking : Enable fast tracking mode 0 : Fan Duty change rate is one step. 1 : Fan Duty change rate is programmable or dynamic depended on Simple Mode

7.2.28 Dynamic Close Loop Fan Control Configuration Registers

Location : Address 49h 4Ah 4Bh 4Ch 4Dh 4Eh 4Fh 50h 51h 52h 53h 54h 55h

Type : Read/Write

Power on default value : Refer to below tables

Address 49h

BIT	7	6	5	4	3	2	1	0
Name	Tcontrol							
Default	50 _{HEX}							

BIT	DESCRIPTION
7-0	Tcontrol : Once CPU temperature is over this setting, dynamic fan duty change rate is activated

Address 4Ah

BIT	7	6	5	4	3	2	1	0
Name	Tbound							
Default	3C _{HEX}							

BIT	DESCRIPTION
7-0	Tbound : Once System temperature is over this setting, dynamic fan duty change rate is activated

Address 4Bh

BIT	7	6	5	4	3	2	1	0
Name	DownFan_Tol_FanDuty				Weight_SYS		Reserved	
Default	35 _{HEX}							

BIT	DESCRIPTION
7 - 4	DownFan_Tol_FanDuty : Tracking tolerance of FanDuty while FanDuty is decreasing 1111 : 15 / ... / 0000 : 0 Ex : Setting 3 => Final FanDuty = (Target FanDuty + 3) while FanDuty is descending.
3 - 2	Weight_STS : Multiplication factor of System fan; the tracking speed of CPU fan responds to this setting. 00 : 0.25 01 : 0.5 10 : 1 11 : 2
1 - 0	Reserved

Address 4Ch

BIT	7	6	5	4	3	2	1	0
Name	Reserved		StepCng_Up			StepCng_Down		
Default	52 _{HEX}							

BIT	DESCRIPTION
7 - 6	Reserved
5 - 3	StepCng_Up : Fixed increasing step of fan duty; only available with Simple Mode = 1
2 - 0	StepCng_Down : Fixed decreasing step of fan duty; only available with Simple Mode = 1

Address 4Dh

BIT	7	6	5	4	3	2	1	0
Name	FCount_FDuty_Weight_High		FCount_FDuty_Step_High					
Default	02 _{HEX}							
Bit	Description							
7 - 6	FCount_FDuty_Weight_High : Multiplication factor of dynamic fan duty change rate for high RPM input							
5 - 0	FCount_FDuty_Step_High : Addition factor of dynamic fan duty change rate for high RPM input							

Address 4Eh

BIT	7	6	5	4	3	2	1	0
Name	FCount_FDuty_Weight_Mid		FCount_FDuty_Step_Mid					
Default	02 _{HEX}							

BIT	DESCRIPTION							
7 - 6	FCount_FDuty_Weight_Mid : Multiplication factor of dynamic fan duty change rate for middle RPM input							
5 - 0	FCount_FDuty_Step_Mid : Addition factor of dynamic fan duty change rate for middle RPM input							

Address 4Fh

BIT	7	6	5	4	3	2	1	0
Name	FCount_FDuty_Weight_Low		FCount_FDuty_Step_Low					
Default	04 _{HEX}							

BIT	DESCRIPTION							
7 - 6	FCount_FDuty_Weight_Low : Multiplication factor of dynamic fan duty change rate for low RPM input							
5 - 0	FCount_FDuty_Step_Low : Addition factor of dynamic fan duty change rate for low RPM input							

Address 50h

BIT	7	6	5	4	3	2	1	0
Name	Generic_Tol_FanInCount							
Default	0A _{HEX}							

BIT	DESCRIPTION
7 - 0	Generic_Tol_FanInCount : Tracking tolerance of input Fan Count under Two Dimension = 1 Ex : Setting 3 => If current FANIN count = (Target FANIN count - 3) ~ (Target FANIN count + 3) then FanDuty will be maintained

Address 51h

BIT	7	6	5	4	3	2	1	0
Name	RPM_Boundary_High[7:0]							
Default	99 _{HEX}							

BIT	DESCRIPTION
7 - 0	RPM_Boundary_High[7:0] : Low byte of high RPM speed boundary setting. It must be fan count format Ex : Fan Count = 1350,000 / RPM

Address 52h

BIT	7	6	5	4	3	2	1	0
Name	RPM_Boundary_Low[7:0]							
Default	1C _{HEX}							

BIT	DESCRIPTION
7 - 0	RPM_Boundary_Low[7:0] : Low byte of low RPM speed boundary setting. It must be fan count format Ex : Fan Count = 1350,000 / RPM

Address 53h

BIT	7	6	5	4	3	2	1	0
Name	RPM_Boundary_High[11:8]					RPM_Boundary_Low[11:8]		
Default	12 _{HEX}							

BIT	DESCRIPTION
7 - 0	RPM_Boundary_High[11:8] : High byte of high RPM speed boundary setting. It must be fan count format RPM_Boundary_Low[11:8] : High byte of low RPM speed boundary setting. It must be fan count format

	Ex : Fan Count = 1350,000 / RPM
--	---------------------------------

Address 54h

BIT	7	6	5	4	3	2	1	0
Name	DownFan_Tol_FanInCount_High							
Default	05 _{HEX}							

BIT	DESCRIPTION
7 - 0	DownFan_Tol_FanInCount_High : Tracking tolerance of input Fan Count under high RPM speed with Two Dimension = 1 & Fast Tracking = 1 Ex : Setting 3 => If the current FANIN count reaches (Target FANIN count - 3) then tracking stops

Address 55h

BIT	7	6	5	4	3	2	1	0
Name	DownFan_Tol_FanInCount_Low							
Default	0A _{HEX}							

BIT	DESCRIPTION
7 - 0	DownFan_Tol_FanInCount_Low : Tracking tolerance of input Fan Count under low RPM speed with Two Dimension = 1 & Fast Tracking = 1 Ex : Setting 3 => If the current FANIN count reaches (Target FANIN count - 3) then tracking stops

7.2.29 SMART FAN™ IV Control Output Step Up Time Register

Location : Address 56h

Type : Read/Write

Power on default value : 0A

BIT	7	6	5	4	3	2	1	0
Name	UpTime (Smart Fan Step Up Time). Unit in 0.1sec. Programmed as the interval of continuous Fan ramping up.							
Default	0A _{HEX}							

This register should not be set to 0. Otherwise, the fan duty will be abnormal.

7.2.30 SMART FAN™ IV Control Output Step Down Time Register

Location : Address 57h

Type : Read/Write

Power on default value : 0A

BIT	7	6	5	4	3	2	1	0
Name	DownTime (Smart Fan Step Down Time). Unit in 0.1sec. Programmed as the interval of continuous Fan ramping Down.							
Default	0A _{HEX}							

This register should not be set to 0. Otherwise, the fan duty will be abnormal.

7.2.31 Fan Output PWM Frequency Prescaler Register

Location : Address 58h

Type : Read/Write

Power on default value : 84

BIT	7	6	5	4	3	2	1	0
Name	CKSEL	FanOutDivisor						
Default	1	0	0	0	0	1	0	0

A wide range of clocks can be selected to satisfy customer needs. The default output frequency is around 25 KHz.

BIT	DESCRIPTION	
7	CLKSEL	BASE Frequency
	0	1.024KHz
	1	125KHz
6-0	Divisor – Clock frequency Divisor.	

There are 2 divisors depending on CKSEL :

If CKSEL equals **1**, then the output clock is simply equal to **125/ (Divisor+1) KHz** .

If CKSEL equals **0**, the output clock is **1.024KHz/MappedDivisor**.

MappedDivisor depends on **Divisor[3:0]** and is described in the table below.

DIVISOR[3:0]	MAPPED DIVISOR	OUTPUT FREQUENCY	DIVISOR[3:0]	MAPPED DIVISOR	OUTPUT FREQUENCY
0000	1	1024Hz	1000	12	85Hz
0001	2	512Hz	1001	16	64Hz
0010	3	341Hz	1010	32	32Hz
0011	4	256Hz	1011	64	16Hz
0100	5	205Hz	1100	128	8Hz
0101	6	171Hz	1101	256	4Hz
0110	7	146Hz	1110	512	2Hz

DIVISOR[3:0]	MAPPED DIVISOR	OUTPUT FREQUENCY	DIVISOR[3:0]	MAPPED DIVISOR	OUTPUT FREQUENCY
0111	8	128Hz	1111	1024	1Hz

7.2.32 Fan Output Start-up Value Register

Location : Address 59h

Type : Read/Write

Power on default value : 30

BIT	7	6	5	4	3	2	1	0
Name	FanStartDuty							
Default	30 _{HEX}							

BIT	DESCRIPTION
7-0	FanStartDuty –control the FANCTL fan output start-up value.

7.2.33 Fan Output Nonstop Value Register

Location : Address 5Ah

Type : Read/Write

Power on default value : 10

BIT	7	6	5	4	3	2	1	0
Name	FanNonStop							
Default	10 _{HEX}							

BIT	DESCRIPTION
7-0	FanNonStop – control the FANCTL fan output nonstop value.

7.2.34 Fan Output Stop Time Register

Location : Address 5Bh

Type : Read/Write

Power on default value : FF

BIT	7	6	5	4	3	2	1	0
Name	FanStopTime							
Default	FF _{HEX}							

BIT	DESCRIPTION
7-0	FanStopTime – control the FANCTL fan stop time from Fan Output Nonstop Value to the off state. Unit in 0.1sec. Ranges from 0.1sec to 25.5sec.

	If set to 0, the fan will never stop.
--	---------------------------------------

7.2.35 FANIN Target Speed Register

Location : Address 5Ch 5Dh

Type : Read/Write

Power on default value : Refer to below tables

FANIN Target Speed High Byte

BIT	7	6	5	4	3	2	1	0
Name	FTSH : FANIN tachometer target speed high byte. The real FANIN RPM value calculation is referred to FANIN COUNT CACLULATION description. 12-bitCount Value bit[11:4]							
Default	60 _{HEX}							

FANIN Target Speed Low Byte

BIT	7	6	5	4	3	2	1	0
Name	FTSL: FANIN tachometer target speed low byte. 12-bitCount Value bit [3:0]				Reserved.			
Default	00 _{HEX}							

In Fan Speed Cruise™ mode, each FANIN tachometer has to have a target fan speed. The NCT7509 will try to tune relative fan output to keep the fan speed of target. The default target speed for FANIN tachometer is 6000_{HEX}.

7.2.36 Tolerance of FANIN Target Speed Register

Location : Address 5Eh

Type : Read/Write

Power on default value : 10

BIT	7	6	5	4	3	2	1	0
Name	Reserved		Tolerance of FANIN Target Speed					
Default	0	0	0	1	0	0	0	0

BIT	DESCRIPTION
7-6	Reserved.
5-0	Tolerance of FANIN Target Speed Tolerance of FANIN tachometer target speed. Tolerance range is 00h~3Fh

7.2.37 Target Temperature of Temperature Input 1 Register

Location : Address 5Fh

Type : Read/Write

Power on default value : 46

BIT	7	6	5	4	3	2	1	0
Name	Temp1 Target Temperature.							
Default	46 _{HEX} (70°C)							

In Thermal Cruise™ mode, each temperature source has to have a target temperature. The NCT7509 will try to tune the fan output to keep the temperature of the target device around the target temperature.

7.2.38 Target Temperature of Temperature Input 2 Register

Location : Address 60h

Type : Read/Write

Power on default value : 46

BIT	7	6	5	4	3	2	1	0
Name	Temp2 Target Temperature.							
Default	46 _{HEX} (70°C)							

In Thermal Cruise™ mode, each temperature source has to have a target temperature. The NCT7509 will try to tune the fan output to keep the temperature of the target device around the target temperature.

7.2.39 Hysteresis of Temperature Input 1 Register

Location : Address 61h

Type : Read/Write

Power on default value : 2B

BIT	7	6	5	4	3	2	1	0
Name	Reserved		Hysteresis of Critical Temperature			Hysteresis of Operation Temperature		
Default	00		5 _{HEX} (5°C)			3 _{HEX} (3°C)		

BIT	DESCRIPTION
7-6	Reserved
5-3	Set the hysteresis tolerance temperature of SMART FAN™ IV Algorithm 000 : 0 °C 001 : 1 °C 010 : 2 °C 011 : 3 °C

BIT	DESCRIPTION
	111 : 7 °C
2-0	Set the hysteresis tolerance temperature of SMART FAN™ IV Algorithm 000 : 0 °C 001 : 1 °C 010 : 2 °C 011 : 3 °C 111 : 7 °C

In Thermal Cruise and SMART FAN™ IV mode, to prevent unstable temperatures from throttling the fan speed, the NCT7509 employs a hysteresis temperature to separate the speed-up/slow-down temperature points.

7.2.40 Hysteresis of Temperature Input 2 Register

Location : Address 62h

Type : Read/Write

Power on default value : 2B

BIT	7	6	5	4	3	2	1	0
Name	Reserved		Hysteresis of Critical Temperature			Hysteresis of Operation Temperature		
Default	00		5 _{HEX} (5°C)			3 _{HEX} (3°C)		

BIT	DESCRIPTION
7-6	Reserved
5-3	Set the hysteresis tolerance temperature of SMART FAN™ IV Algorithm 000 : 0 °C 001 : 1 °C 010 : 2 °C 011 : 3 °C 111 : 7 °C
2-0	Set the hysteresis tolerance temperature of SMART FAN™ IV Algorithm 000 : 0 °C 001 : 1 °C 010 : 2 °C 011 : 3 °C 111 : 7 °C

In Thermal Cruise and SMART FAN™ IV mode, to prevent unstable temperatures from throttling the fan speed, the NCT7509 employs a hysteresis temperature to separate the speed-up/slow-down temperature points.

7.2.41 SMART FAN™ IV Temperature and PWM Registers Register

Location : Address 63h ~ 80h

Type : Read/Write

Power on default value: Refer to below tables

SMART FAN™ IV is an algorithm providing a table mapping mechanism to translate the temperature information into output fan duties or desired Fan speed. The mapping table requires 2 domains for the translation. In the table, a certain temperature corresponds to a certain duty or RPM. T1-T7 (Temperature) and PWM1-PWM7 (PWM fan output values) are used to define the table. There are totally two tables reside in the NCT7509.

Relative Register-at SMART FAN™ IV Control Mode Table

TABLE	NAME	ADDRESS	DEFAULT	TYPE
Table1	Transition Point : T1	63 _{HEX}	0A _{HEX}	Read/Write
	Transition Point : T2	64 _{HEX}	14 _{HEX}	Read/Write
	Transition Point : T3	65 _{HEX}	1E _{HEX}	Read/Write
	Transition Point : T4	66 _{HEX}	28 _{HEX}	Read/Write
	Transition Point : T5	67 _{HEX}	32 _{HEX}	Read/Write
	Transition Point : T6	68 _{HEX}	3C _{HEX}	Read/Write
	Transition Point : T7	69 _{HEX}	55 _{HEX}	Read/Write
	Critical Point	6A _{HEX}	5A _{HEX}	Read/Write
	Y-axis Transition Point : PWM1	6B _{HEX}	28 _{HEX}	Read/Write
	Y-axis Transition Point : PWM2	6C _{HEX}	50 _{HEX}	Read/Write
	Y-axis Transition Point : PWM3	6D _{HEX}	78 _{HEX}	Read/Write
	Y-axis Transition Point : PWM4	6E _{HEX}	96 _{HEX}	Read/Write
	Y-axis Transition Point : PWM5	6F _{HEX}	B4 _{HEX}	Read/Write
	Y-axis Transition Point : PWM6	70 _{HEX}	D2 _{HEX}	Read/Write
	Y-axis Transition Point : PWM7	71 _{HEX}	F0 _{HEX}	Read/Write
Table2	Transition Point : T1	72 _{HEX}	19 _{HEX}	Read/Write
	Transition Point : T2	73 _{HEX}	1E _{HEX}	Read/Write
	Transition Point : T3	74 _{HEX}	23 _{HEX}	Read/Write
	Transition Point : T4	75 _{HEX}	28 _{HEX}	Read/Write
	Transition Point : T5	76 _{HEX}	2D _{HEX}	Read/Write
	Transition Point : T6	77 _{HEX}	32 _{HEX}	Read/Write
	Transition Point : T7	78 _{HEX}	37 _{HEX}	Read/Write
	Critical Point	79 _{HEX}	3C _{HEX}	Read/Write
	Y-axis Transition Point : PWM1	7A _{HEX}	28 _{HEX}	Read/Write
	Y-axis Transition Point : PWM2	7B _{HEX}	50 _{HEX}	Read/Write
	Y-axis Transition Point : PWM3	7C _{HEX}	78 _{HEX}	Read/Write

TABLE	NAME	ADDRESS	DEFAULT	TYPE
	Y-axis Transition Point : PWM4	7D _{HEX}	96 _{HEX}	Read/Write
	Y-axis Transition Point : PWM5	7E _{HEX}	B4 _{HEX}	Read/Write
	Y-axis Transition Point : PWM6	7F _{HEX}	D2 _{HEX}	Read/Write
	Y-axis Transition Point : PWM7	80 _{HEX}	F0 _{HEX}	Read/Write

T1 – T7

BIT	7	6	5	4	3	2	1	0
Name	SMART FAN TM IV Temperature							
Default	Refer to SMART FAN TM IV Control Mode Table							

PWM1 – PWM7

BIT	7	6	5	4	3	2	1	0
Name	SMART FAN TM IV PWM							
Default	Refer to SMART FAN TM IV Control Mode Table							

7.2.42 Remote Diode Temperature Filter and Alert Mode Setting Register

Location : Address BFh

Type : Read/Write

Power on default value : 00

BIT	7	6	5	4	3	2	1	0
Name	Reserved					RT1F		ALERT_MD
Default	00 _{HEX}							

BIT	DESCRIPTION
2-1	RT1F – Remote diode temperature 1 filter setting 00 = No filter selected 01 or 10 = Filter level 1 selected 11 = Filter level 2 selected
0	ALERT_MD – ALERT mode configuration 0 = Interrupt or SMBus TM alert mode 1 = Comparator mode

7.2.43 Chip ID Register

Location : Address FDh

Type : Read Only

Power on default value : 50

BIT	DESCRIPTION
-----	-------------

7-0	Chip ID. Chip ID of NCT7509 is 50 _{HEX}
-----	--

7.2.44 Vendor ID Register

Location : Address FEh

Type : Read Only

Power on default value : 50

BIT	DESCRIPTION
7-0	Vendor ID. Vendor ID of NCT7509 is 50 _{HEX}

7.2.45 Device ID Register

Location : Address FFh

Type : Read Only

Power on default value : 9x

BIT	DESCRIPTION
7-0	Device ID. Device ID of NCT7509 is 9x _{HEX} (x=0,1,2...)

8. ELECTRICAL CHARACTERISTICS

8.1 Absolute Maximum Ratings

PARAMETER	RATING	UNIT
Power Supply Voltage	$3.3V \pm 5\%$	V
Input Voltage	-0.3 to +3.6	V
Operating Temperature	-40 to +125	°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.

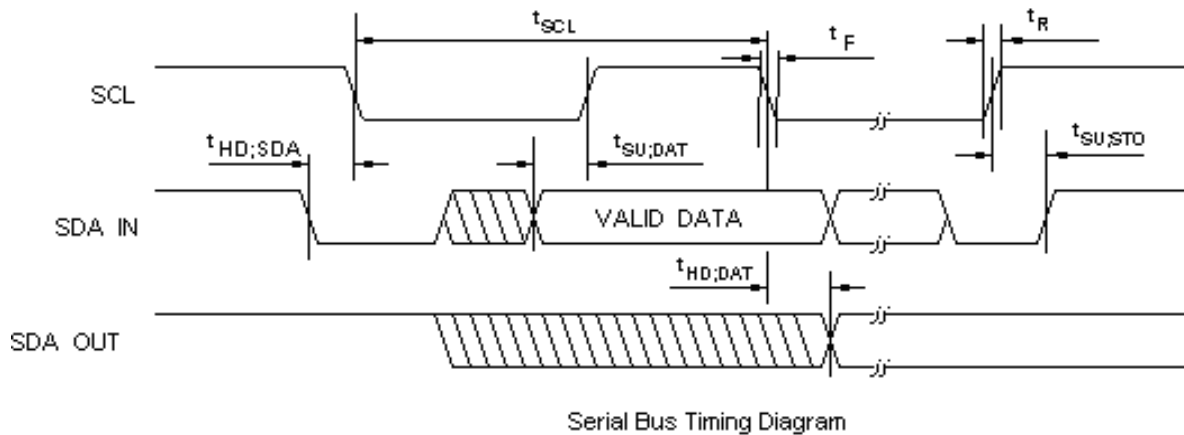
8.2 DC Characteristics

($T_a = 0^\circ\text{C}$ to 70°C , $V_{DD} = 3.3V \pm 5\%$, $GND = 0V$)

PARAMETER	SYM.	MIN.	TYP.	MAX.	UNIT	CONDITIONS
OD ₁₂ – Open-drain output pin with source-sink capability of 12 mA						
Output Low Voltage	V _{OL}			0.4	V	I _{OL} = 12 mA
IN _{ts} - TTL level Schmitt-triggered input pin						
Input Low Voltage	V _{IL}			0.8	V	V _{DD} = 3.3V
Input High Voltage	V _{IH}	2.0			V	V _{DD} = 3.3V
Input High Leakage	I _{LIH}			+10	μA	V _{IN} =3.3V
Input Low Leakage	I _{LIL}			-10	μA	V _{IN} =0V

8.3 AC Characteristics

SMBus™ Interface



PARAMETER	SYMBOL	MIN.	MAX.	UNIT
SCL clock period	t_{SCL}	2.5		uS
Start condition hold time	$t_{HD;SDA}$	1.5		uS
Stop condition setup-up time	$t_{SU;STO}$	1		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

9. ORDERING INFORMATION

PART NO.	PACKAGE	SUPPLIED AS	PRODUCTION FLOW
NCT7509Y	DFN, 10pin Green package	T Shape: 5,000 units/T&R	Commercial, 0°C to +70°C
NCT7509W	MSOP, 10pin Green package	T Shape: 4,000 units/T&R	Commercial, 0°C to +70°C

10. TOP MARKING SPECIFICATION

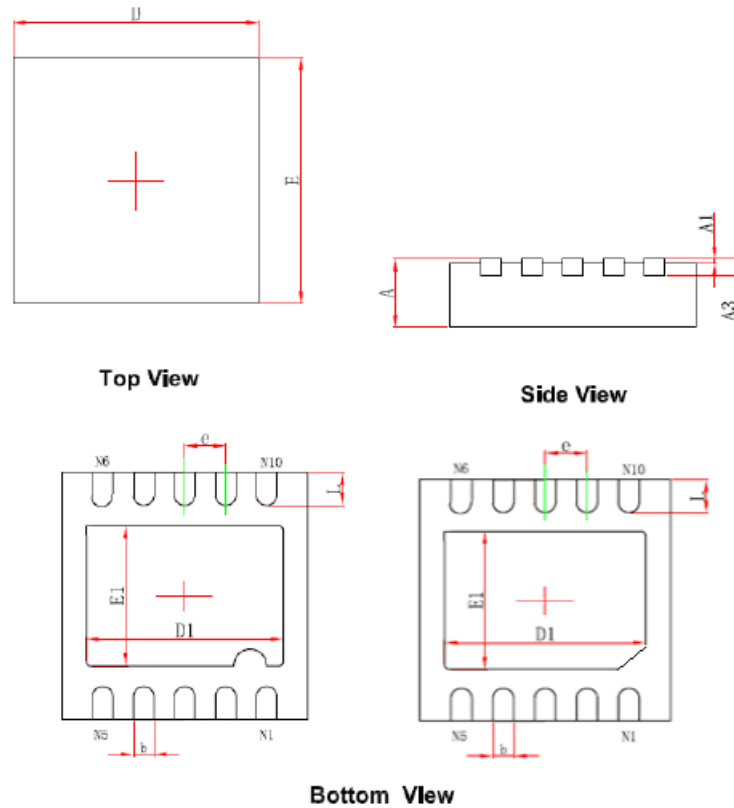


1st line: Part number: 7509Y means the NCT7509Y
7509W means the NCT7509W

2nd line: Assembly tracking code
0 22: packages made in year 2010, week 22
G: Assembly house code
B: Product version

11. PACKAGE DRAWING AND DIMENSIONS

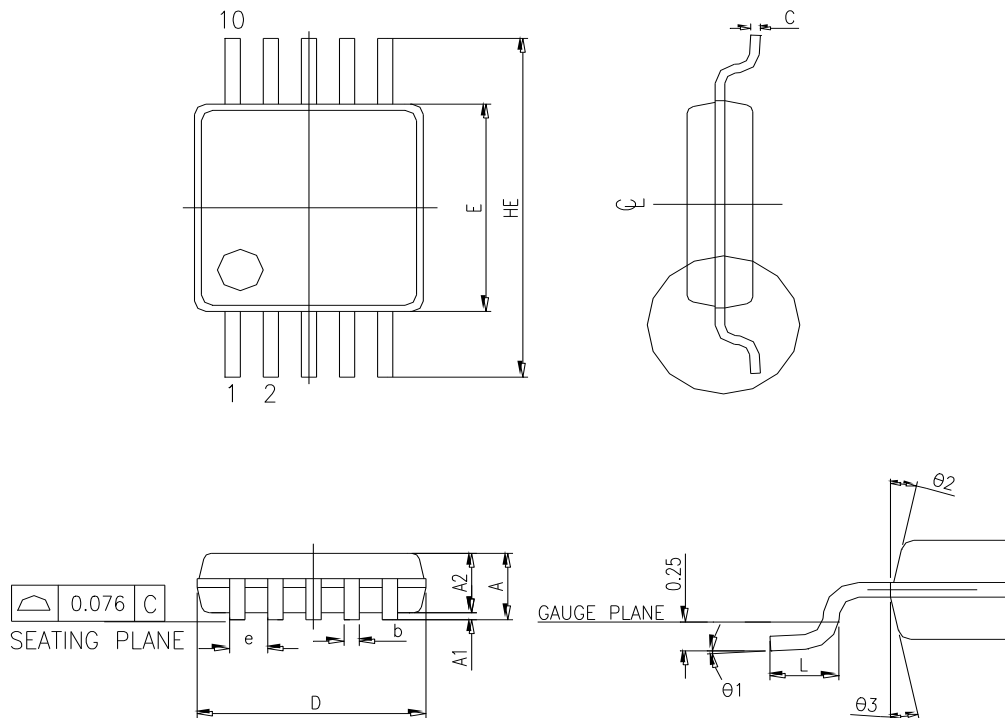
11.1 10L DFN (3X3 MM²; 0.8 MM)



Note: The thermal pad in the Bottom View will be different due to different assembly subcons.

Symbol	Domentions In Millimeters	
	Min	Max
A	0.700	0.800
A1	0.000	0.050
A3	0.203REF	
D	2.900	3.100
E	2.900	3.100
D1	2.300	2.600
E1	1.500	1.800
b	0.180	0.300
c	0.500TYP	
L	0.324	0.476

11.2 10L MSOP (3X3 MM²)



CONTROLLING DIMENSION:MILLIMETERS

SYMBOL	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	---	---	1.10	---	---	0.043
A1	0.05	---	0.15	0.002	---	0.006
A2	0.81	0.86	0.91	0.032	0.034	0.036
c	0.13	---	0.23	0.005	---	0.009
b	0.25	---	0.40	0.17	---	0.27
D	2.90	3.00	3.10	0.114	0.118	0.122
E	2.90	3.00	3.10	0.114	0.118	0.122
HE	4.90 BSC			0.193 BSC		
L	0.445	0.55	0.648	0.0175	0.0217	0.0255
$\theta 1$	0°		6°	0°		6°
e	0.50 BSC			0.02 BSC		

12. REVISION HISTORY

VERSION	DATE	PAGE	DESCRIPTION
0.1	12/18/2008	N.A.	New create
0.2	5/26/2009		First released.
0.5	07/21/2010	2, 41	Update the key specification and add the top marking specification
0.51	07/28/2010	All	Modify some descriptions
0.6	09/15/2010	All	Modify some descriptions Update the ordering information
1.0	08/15/2012	All	All versions before 1.0 are preliminary versions

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