NCT7511Y

Nuvoton

H/W Monitoring IC

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1. GENERAL DESCRIPTION

The NCT7511Y is a Nuvoton Hardware Monitor IC, which can monitor several critical hardware parameters of the systems, including the temperature and fan speeds, to make the system work stably and efficiently.

The NCT7511Y supports one on-die and two remote temperature sensors with SMBus interface. There's a 10-bit analog-to-digital converter (ADC) is built inside NCT7511Y, to convert the monitored temperature value. Both of the remote temperature inputs can be connected to CPU/GPU thermal diode or any diode sensors.

The NCT7511Y has 1 fan control groups and two GPIO pins. The SMART FAN™ IV mode of the fan speed control provides 4 sets of temperature setting points, and they can also control the duty cycle of fan outputs. It provides an easy method to implement quiet and cooling solution with maximum safety and flexibility.

Meanwhile, there're two pure hardware event pins ALERT# and T_CRIT# for independent alarm signals, and all threshold values could be set for system protection without timing delay.

2. FEATURES

2.1 Temperature Measurement

- Measure the temperature with high accuracy.
- One local on-die thermal sensor
- Two pairs thermal diode (current mode) temperature channels

2.2 Fan Speed Monitoring and Control

- SMART FAN™ IV mode or Manual mode to control the fan speed
- One fan control output multi-function (PWM/DC mode supported)
- One fan tachometer input multi-function

2.3 Event Notification

- Supports 2 alarm outputs: ALERT# and T_CRIT# signals to activate system protection.
- ALERT# output supports SMBus™ 2.0 ARA function
- T_CRIT# supports Hardware Power-on setting

2.4 General

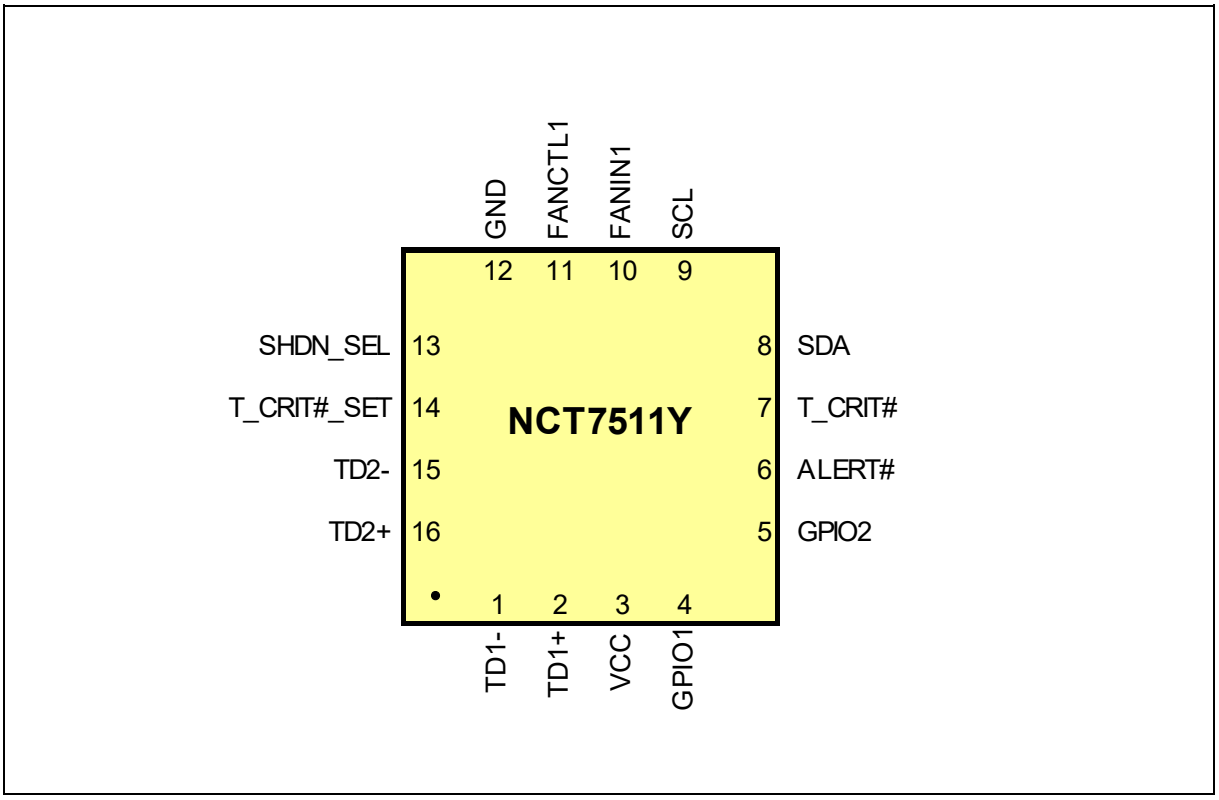
- Two GPIO pins
- I²C® Compatible System Management bus (SMBus)
- 3.3V±5% V_{CC} operation
- 16-pin QFN Halogen free package (RoHS-compliant and TSCA-compliant).

3. KEY SPECIFICATIONS

- Temperature Sensor Accuracy
  - Remote Diode Sensor Accuracy (25~85°C) ± 1°C typ.
  - On-chip Temperature Sensor Accuracy (25~70°C) ± 2°C typ.
  - Remote Temperature Sensor Resolution 0.125 ℃
  - Local Temperature Sensor Resolution 1 ℃
- Programming from EEPROM support
- FANIN Monitoring Accuracy ± 7%
- Supply Voltage 3.3V ± 5%
- Operating Supply Current 3.5mA typ.
- Operating Temperature Range -40°C ~ 85°C *1

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

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)
OUT_{12}	Output pin with 12 mA sink/source capability
AOUT	Output pin (Analog)
P	Power or Ground Pin

5.2 PIN DISCRIPTION

PIN NO.	PIN NAME	I/O	FUNCTION
1	**TD1-**	AIN	Connect to Thermal Diode 1 Cathode.
2	**TD1+**	AIN	Connect to Thermal Diode 1 Anode.
3	**VCC**	P	Power supply, Voltage input 3.3V±5%
4	**GPIO1**	IN_{ts} / OD_{12}	General purpose I/O function.
5	**GPIO2**	IN_{ts} / OD_{12}	General purpose I/O function.
6	**ALERT#**	OD_{12}	Alarm output, for interrupt control
7	**T_CRIT#**	OD_{12}	T_CRIT# alarm output, for interrupt or shutdown control.
8	**SDA**	IN_{ts}/ OD_{12}	SMBus bi-directional data.
9	**SCL**	IN_{ts}	SMBus Clock.
10	**FANIN1**	IN_{ts}	Fan tachometer input
11	**FANCTL1**	OUT_{12}/ AOUT	It can be configured to PWM/DC mode by registers. Default is PWM output. As DC output, 256 steps output voltage scaled to 0~VCC.
12	**GND**	P	Power supply ground
13	**SHDN_SEL**	AIN	Selects the hardware shutdown channel and operating mode
14	**T_CRIT#_SET**	AIN	Voltage input to set the Critical/Thermal Shutdown threshold
15	**TD2-**	AIN	Connect to Thermal Diode 2 Cathode.
16	**TD2+**	AIN	Connect to Thermal Diode 2 Anode.

6. FUNCTION DESCRIPTION

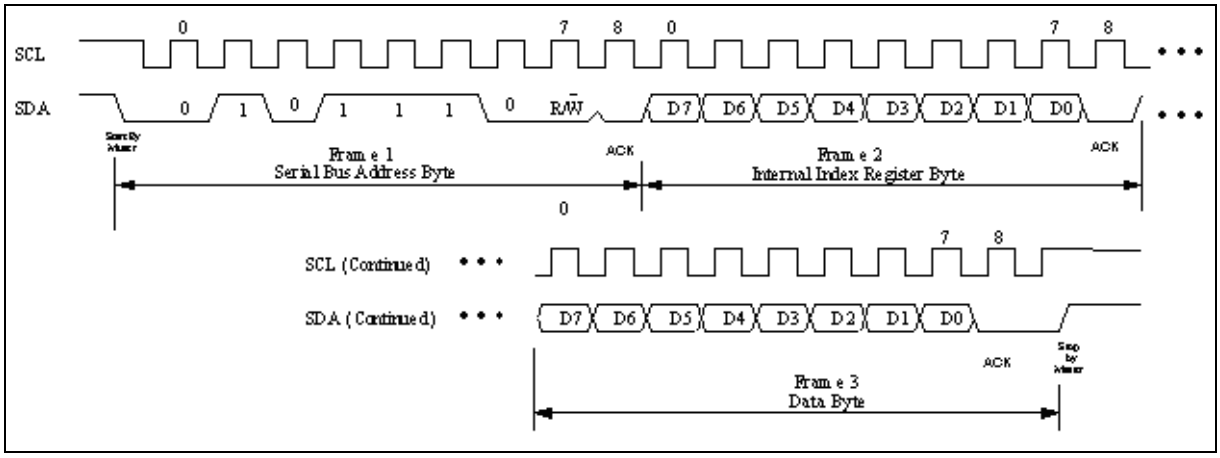
6.1 GENERAL DESCRIPTION

The NCT7511Y is a SMBus™ interface device to provide one on-die temperature sensor, two set of inputs for thermal diode sensors, 1 fan control groups, and two GPIO pins. The NCT7511Y also provides ALERT# and T_CRIT# alarm signals for event notification.

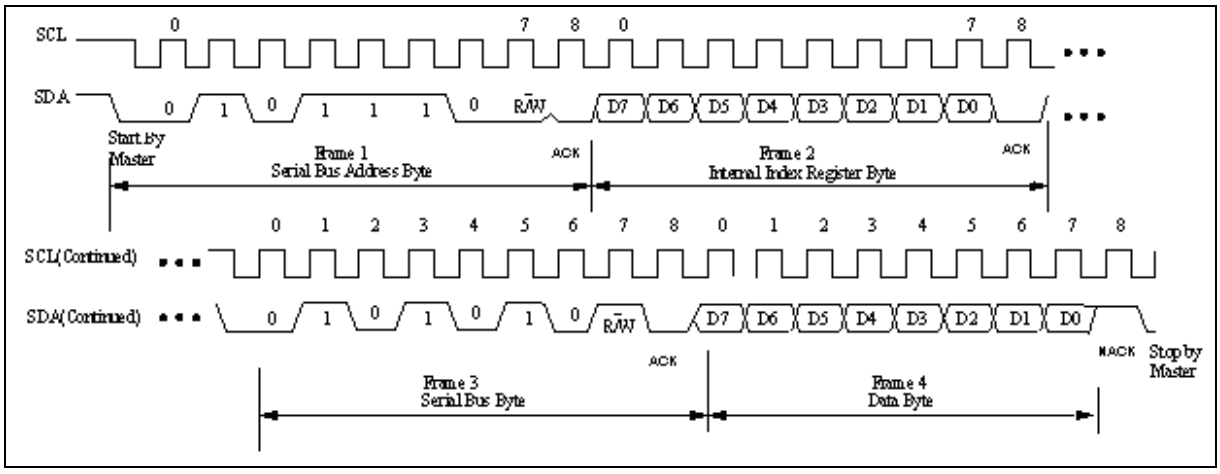
6.2 ACCESS INTERFACE

NCT7511Y provides SMBus to access the internal register, 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

NCT7511Y I²C/SMBus address is 0101110xb (x is R/W bit).

6.4 TEMPERATURE MONITOR 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 FAN_IN Count Calculation

The FAN_IN tachometer high byte and low byte are combined to 13-bitCountValue. Real RPM (Rotate per Minute) calculation should follow the formula:

$$FanSpeed(RPM) = \frac{1.35 \times 10^6}{(13 - bitCountValue) \times (FanPoles/4)}$$

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.

6.6 FAN_OUT Duty Cycle Calculation

The NCT7511Y 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:

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

6.7 SMART FAN™ IV Control Parameters

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

6.7.1 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.

6.7.2 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.

6.7.3 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.

6.7.4 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.



Figure 6-1 SMART FAN™ Control Parameters

6.8 SMART FAN™ IV

SMART FAN™ IV supports Fan Duty Outputs Mode and Close Loop Fan Control (RPM) Mode to control the fan speed.

There're 3 slopes can be obtained by setting FanDuty/RPM1~FanDuty/RPM4 and T1~T4 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/RPM is the target, then the slope:

$$X2 = \frac{(FanDuty3 / RPM3) - (FanDuty2 / RPM2)}{(T3 - T2)}$$

Fan Output:

$$Target\ FanDuty\ or\ RPM = (FanDuty2\ or\ RPM2) + (Tx - T2) \cdot X2$$

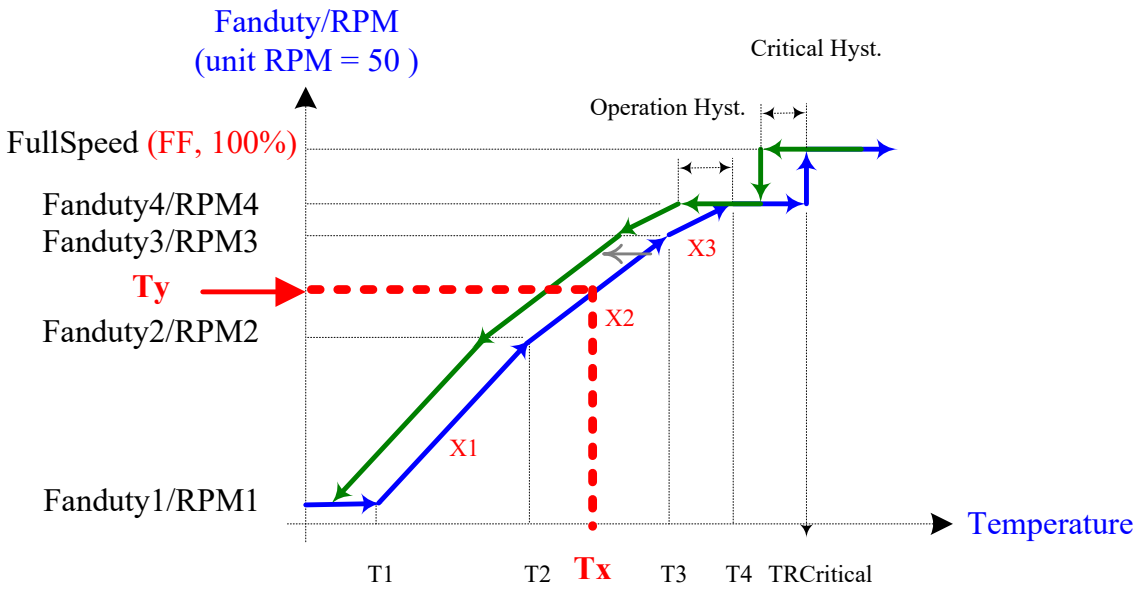
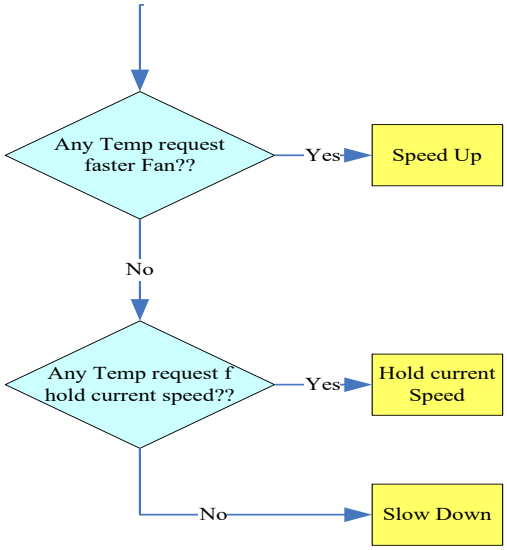


Figure 6-2 SMART FAN™ IV Mechanism

In addition, SMART FAN™ IV 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.)

NCT7511Y provides 3 temperature source selections to map the fan, the algorithm will make a decision to control the fan as below figure:



6.9 ALERT# Output

The NCT7511Y 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.

6.9.1 ALERT# Output Mechanism

Figure 6-3 shows the mechanism of the ALERT# output. In this mode, the NCT7511Y 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.

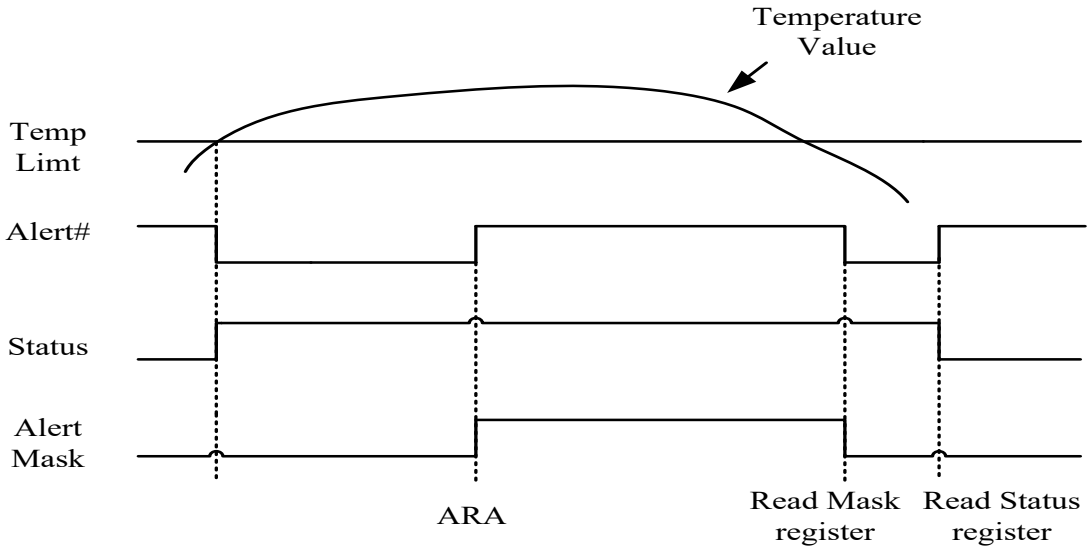


Figure 6-3 ALERT# Output Mechanism

6.9.2 ALERT Response Address

Figure 6-4 shows the mechanism of the SMBus ALERT Response Address (ARA) support on ALERT# output. In this mode, the ALERT# output of the NCT7511Y is connected to the SMBus alert line which has more than one device connected to it. Through such and implementation, SMBus alert mode can assist the master in resolving which salve 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 ARA occurs from master (Alert Response Address is 0001100x). Meanwhile, the NCT7511Y 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.

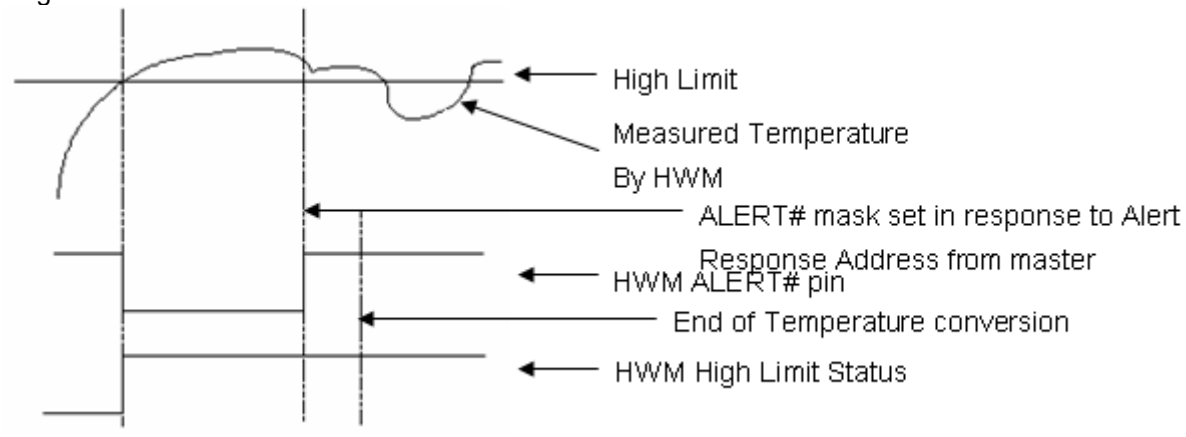


Figure 6-4 SMBus ARA Mechanism

6.10 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. Figure 6-5 shows this mechanism.

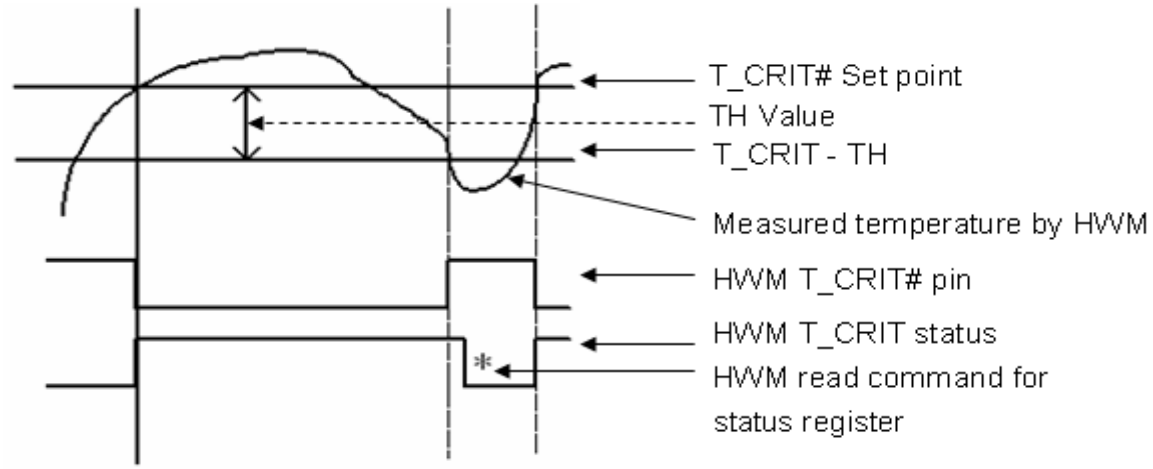


Figure 6-5 T_CRIT# Output Mechanism

6.11 SHDN_SEL

The NCT7511Y has a strapping input pin (SHDN_SEL) allowing for configuration of the hardware Critical/Thermal Shutdown input channel.

The pull-up resistor used on SHDN_SEL pin identifies which configuration setting is used as shown in table.

PULL-UP RESISTOR（Ω）	MODE / SHUTDOWN CHANNEL
4.7K ~ 10K	RTD1
15K	LTD & EEPROM（note1）
22K	RTD2 & EEPROM
≧33K	RTD1 & EEPROM

Note 1：Load registers setting from EEPROM when power on.

6.12 T_CRIT#_SET

The NCT7511Y's T_CRIT#_SET pin is an analog input pin to set the Critical/Thermal shutdown temperature by trapping voltage when system power on. The thermal shutdown temperature is ranging from 65℃ to 127℃ as shown in table.

Trapping Temp(HEX)	Trapping Temp(DEC)	Trapping Volt(V)
41	65	1.112
41	65	1.144
41	65	1.176
42	66	1.207
43	67	1.239
44	68	1.271
45	69	1.303
46	70	1.334
47	71	1.366
48	72	1.398
49	73	1.430
4a	74	1.461
4b	75	1.493
4c	76	1.525
4d	77	1.557
4e	78	1.589
4f	79	1.620
50	80	1.652
51	81	1.684

Trapping Temp(HEX)	Trapping Temp(DEC)	Trapping Volt(V)
52	82	1.716
53	83	1.747
54	84	1.779
55	85	1.811
56	86	1.843
57	87	1.875
58	88	1.906
59	89	1.938
5a	90	1.970
5b	91	2.002
5c	92	2.033
5d	93	2.065
5e	94	2.097
5f	95	2.129
60	96	2.160
61	97	2.192
62	98	2.224
63	99	2.256
64	100	2.288
65	101	2.319
66	102	2.351
67	103	2.383
68	104	2.415
69	105	2.446
6a	106	2.478
6b	107	2.510
6c	108	2.542
6d	109	2.573
6e	110	2.605
6f	111	2.637
70	112	2.669
71	113	2.701
72	114	2.732
73	115	2.764
74	116	2.796
75	117	2.828

Trapping Temp(HEX)	Trapping Temp(DEC)	Trapping Volt(V)
76	118	2.859
77	119	2.891
78	120	2.923
79	121	2.955
7a	122	2.986
7b	123	3.018
7c	124	3.050
7d	125	3.082
7e	126	3.114
7f	127	3.145

6.13 Self-Programming from EEPROM

The NCT7511Y supports self-programming through an external I2C EEPROM during NCT7511Y power-on. The EEPROM is recommended to be 24C02 type. During 200ms period after power on, NCT7511Y will detect if the external EEPROM exists by issuing the SMBus Byte Read command with 50KHz SMBus clock frequency. If a NACK of SMBus protocol is detected, NCT7511Y will stop self-programming, Otherwise, NCT7511Y will keep loading data from external EEPROM sequentially to Bank0 Index 00h~E2h registers. Therefore, other SMBus master has to avoid from accessing NCT7511Y during the 200ms after power-on.

Please refer below for self-programming implementation.

1. NCT7511Y pin8/pin9 is SMBus interface. These two pins usually act for slave function.
2. When NCT7511Y's SHDN_SEL pin is pulled-up to 15K~33K (please refer to section 6.11), the self-programming from EEPROM function will be enabled, and pin8/pin9 will act as SMBus master.
3. The EEPROM address has to be ACh (1010110x).
4. The EEPROM is recommended to be 24C02 type.
5. Loading register mapping is from Bank 0 Index 00h to E2h. The following figure shows the default value.

00h :	00	1A	1B	1D	1A	C0	00	00	00	D4	00	00	00	00	00	00
10h :	FF	00	00	00	41	00	00	00	00	00	00	00	00	00	00	00
20h :	00	01	55	00	01	05	02	03	00	04	EE	80	F4	32	40	00
30h :	55	00	55	00	55	00	55	00	55	00	64	64	64	64	64	FF
40h :	00	FF	00	FF	00	FF	00	CC	CC	FF	FF	FF	F8	F8	F8	7F
50h :	3F	07	8F	BF	3F	00	3F	00	00	00	00	00	00	00	00	00
60h :	7F	7F	7F	00	00	00	00	00	00	00	8F	8F	8F	02	0A	0A
70h :	7F	84	84	84	53	53	53	30	FF	00	80	00	00	FF	FF	FF
80h :	19	23	2D	37	3C	8C	AA	C8	E6	FF	FF	FF	FF	FF	FF	FF

90h：	19	23	2D	37	3C	8C	AA	C8	E6	FF	FF	FF	FF	FF	FF	FF
A0h：	19	23	2D	37	3C	8C	AA	C8	E6	FF	FF	FF	FF	FF	FF	FF
B0h：	4D	4E	4E	00	00	00	00	00	00	00	FF	FF	FF	FF	00	0B
C0h：	00	3D	3D	3D	00	00	00	39	33	33	FF	00	00	00	40	00
D0h：	00	AA	0A	0A	0A	0A	02	F2	81	1E	00	18	07	41	7F	70
E0h：	E4	00	00													

Important : Please just modify the register that described in the datasheet ; the undescribed register must be kept at default value of the above figure.

6. The self-programming from EEPROM only supports Bank0 regsiters.

Other SMBus master has to avoid from accessing NCT7511Y during the 200ms after power-on.

7. REGISTER DESCRIPTION

7.1 REGISTER MAP

Idx	Register Name	Att	Df	7	6	5	4	3	2	1	0
1	Read RTD1 MSB	R		MNTRTD1[10:3]							
2	Read RTD2 MSB	R		MNTRTD2[10:3]							
4	Read LTD MSB	R		MNTLTD[10:3]							
5	Read Temp LSB	R		MNTTD_Lsb[2:0]			RSV				
10	Read Fan Count 1MSB	R		MNTFAN1[12:5]							
13	Read Fan Count 1LSB	R		MNTFAN_Lsb[4:0]					RSV		
14	T_CRIT#_SET Point	R		T_CRIT#_SET Point							
16	Interrupt Alert Status Register	R		RSV		TCRIT	GPIO	FAN	High	Low	Fault
17	Diode Fault Alert Status	R		RSV						STS_DF2	STS_DF1
18	Low Alert Status	R		RSV				STS_AL4	RSV	STS_AL2	STS_AL1
19	High Alert Status	R		RSV				STS_AH4	RSV	STS_AH2	STS_AH1
1A	Fan Alert Status	R		RSV			FAN_TAR1	RSV			FAN_FC1
1B	T_CRIT# Alert Status	R		RSV				STS_TC4	RSV	STS_TC2	STS_TC1
1C	GPIO Alert Stuts	R		RSV						STS_GPIO2	STS_GPIO1
20	T_CRIT# Real Time Status	R		RSV				LTD_Texc	RSV	RTD2_Texc	RTD1_Texc
21	START	R/W	01	Msk_Alert	RSV						START
22	Mode Selection	R/W	55	RSV	EnLTD	RSV		RTD2_MD		RTD1_MD	
24	Fan Enable	R/W	01	RSV							EnFan1
26	Conversion Rate	R/W	02	RSV						ConvRate[1:0]	
27	Fault Queue	R/W	03	RSV						FaultQueue[1:0]	
28	Alert High link to T_CRIT#	R/W	00	RSV					SYS3	SYS2	SYS1
30	RTD1 Temp High Limit	R/W	55	RTD1_HL							
31	RTD1 Temp Low Limit	R/W	00	RTD1_LL							
32	RTD2 Temp High Limit	R/W	55	RTD2_HL							
33	RTD2 Temp Low Limit	R/W	00	RTD2_LL							
36	LTD Temp High Limit	R/W	55	LTD_HL							
37	LTD Temp Low Limit	R/W	00	LTD_LL							
3A	RTD1 T_CRIT# Threshold	R/W	64	T_CRIT#_RTD1							
3B	RTD2 T_CRIT# Threshold	R/W	64	T_CRIT#_RTD2							
3D	LTD T_CRIT# Threshold	R/W	64	T_CRIT#_LTD							
49	FANIN1 Limit low Byte	R/W	FF	FANIN1_HL[7:0]							
4C	FANIN1 Limit high byte	R/W	F8	FANIN1_HL[12:8]					RSV		
4F	Alert Mask function	R/W	7F	Msk_Alert	Msk_TC	Msk_GPIO	Msk_TART	Msk_FC	Msk_AH	Msk_AL	Msk_DF

Idx	Register Name	Att	Df	7	6	5	4	3	2	1	0
50	Alert / SMI Mask Temp Channel	R/W	3F	RSV				Msk_LTD	RSV	Msk_RTD2	Msk_RTD1
51	Alert / SMI Mask FAN Channel	R/W	07	RSV							Msk_Fan1
53	T_CRIT# Mask	R/W	BF	Msk_ALL	RSV			Msk_LTD	RSV	Msk_RTD2	Msk_RTD1
54	GPIO Alert Mask	R/W	3F	RSV						Msk_GPIO2	Msk_GPIO1
56	GPIO mode	R/W	3F	RSV						GPIO2 Mode	GPIO1 Mode
57	GPIO output type	R/W	00	RSV						GPIO2 OB	GPIO1 OB
58	GPIO input data	R		RSV						GPIO2 in	GPIO1 in
59	GPIO output data	R/W	00	RSV						GPIO2 out	GPIO1 out
5E	Fan Control Output Type	R/W	00	RSV							EnDCFAN1
5F	Fan Control Output Mode	R/W	00	RSV			PWM1_Pol	RSV			PWM1_OD
60	Fan Control 1 Output Value	RW	7F	FANDuty1							
63	Close-Loop Fan Control RPM mode Register	RW	00	RSV		TwoDimension	RSV		RPM_HIGH_EN	RSV	
64	Temperature to Fan mapping Relationships	RW	00	RSV			Temp2FanSelect	RSV			Temp1FanSelect
65	Temperature to Fan mapping Relationships	RW	00	RSV							Temp3FanSelect
66	Configuration Register 1	RW	00	Temp2_Share_En	Temp2_Share_Sel			Temp1_Share_En	Temp1_Share_Sel		
67	Configuration Register 2	RW	00	RSV				Temp3_Share_En	Temp3_Share_Sel		
68	Configuration Register 3	RW	00	RSV	Temp2_Sour_Sel			RSV	Temp1_Sour_Sel		
69	Configuration Register 4	RW	00	RSV					Temp3_Sour_Sel		
6A	Fan1_Target	R		Fan1_Target[7:0]							
6D	Close-Loop Fan Control RPM mode Tolerance	RW	00	RSV					Generic_Tol_RPM		
6E	Fanctl Step Up Time	RW	0A	UpTime							
6F	Fanctl Step Down Time	RW	0A	DownTime							
70	DefaultFanSpeed	RW	7F	DefaultFanSpeed							
71	PWM1 Prescalar	RW	84	FanOutDivisor1[7]	FanOutDivisor1[6:0]						
74	Temp1 Hysteresis	RW	53	RSV	Criti_HysT1			RSV	Oper_HysT1		
75	Temp2 Hysteresis	RW	53	RSV	Criti_HysT2			RSV	Oper_HysT2		
76	Temp3 Hysteresis	RW	53	RSV	Criti_HysT3			RSV	Oper_HysT3		
77	Fanctl1 Start Duty Cycle	RW	30	StartDutyCycle							
78	Stop Time of Fanctl1	RW	FF	StopTime							
79	NonStop Enable	RW	00								NonStop_Fan1
80	Table 1 Transition Point 1	RW	00	Temp1Table_TR1							
81	Table 1 Transition Point 2	RW	00	Temp1Table_TR2							
82	Table 1 Transition Point 3	RW	00	Temp1Table_TR3							

Idx	Register Name	Att	Df	7	6	5	4	3	2	1	0
83	Table 1 Transition Point 4	RW	00	Temp1Table_TR4							
84	Table 1 Critical Point	RW	00	Temp1Table_TRCritical							
85	Table 1 Y-axis Transition Point 1	RW	00	Temp1Table_FL1							
86	Table 1 Y-axis Transition Point 2	RW	00	Temp1Table_FL2							
87	Table 1 Y-axis Transition Point 3	RW	00	Temp1Table_FL3							
88	Table 1 Y-axis Transition Point 4	RW	00	Temp1Table_FL4							
90	Table 2 Transition Point 1	RW	00	Temp2Table_TR1							
91	Table 2 Transition Point 2	RW	00	Temp2Table_TR2							
92	Table 2 Transition Point 3	RW	00	Temp2Table_TR3							
93	Table 2 Transition Point 4	RW	00	Temp2Table_TR4							
94	Table 2 Critical Point	RW	00	Temp2Table_TRCritical							
95	Table 2 Y-axis Transition Point 1	RW	00	Temp2Table_FL1							
96	Table 2 Y-axis Transition Point 2	RW	00	Temp2Table_FL2							
97	Table 2 Y-axis Transition Point 3	RW	00	Temp2Table_FL3							
98	Table 2 Y-axis Transition Point 4	RW	00	Temp2Table_FL4							
A0	Table 3 Transition Point 1	RW	00	Temp3Table_TR1							
A1	Table 3 Transition Point 2	RW	00	Temp3Table_TR2							
A2	Table 3 Transition Point 3	RW	00	Temp3Table_TR3							
A3	Table 3 Transition Point 4	RW	00	Temp3Table_TR4							
A4	Table 3 Critical Point	RW	00	Temp3Table_TRCritical							
A5	Table 3 Y-axis Transition Point 1	RW	00	Temp3Table_FL1							
A6	Table 3 Y-axis Transition Point 2	RW	00	Temp3Table_FL2							
A7	Table 3 Y-axis Transition Point 3	RW	00	Temp3Table_FL3							
A8	Table 3 Y-axis Transition Point 4	RW	00	Temp3Table_FL4							
C1	TD1 Offset	R/W	00	RSV		Offset_TD1					
C2	TD2 Offset	R/W	00	RSV		Offset_TD2					
E3	Programmable Temperature 1	R/W	00	PGM_TEMP1[7:0]							
E4	Programmable Temperature 2	R/W	00	PGM_TEMP2[7:0]							
FC	SOFT RESET	W		INIT				RSV			

7.2.43 Fan Control Output Mode Register

Location : Index 5Fh

Type : Read/Write

Power on default value : 00h

BIT	7	6	5	4	3	2	1	0
NAME	RSV			PWM1_POL	RSV			PWM1_OD
FUNC.	**PWM1_POL :** 1 indicates the FANCTL1 PWM output is inverted. **PWM1_OD :** 0 indicates the FANCTL1 PWM output is push pull. 1 indicates the FANCTL1 PWM output is open drain.							

7.2.44 Fan Control 1 Output Value Register

Location : Index 60h

Type : Read/Write for Manual mode , Read only for Smart Fan control

Power on default value :7Fh

BIT	7	6	5	4	3	2	1	0
NAME	FANDuty1							
FUNC.	**FANDuty1 :** FANCTL1 output value.							

Note : Please refer the APN2 if want to control the fan speed in I2C fast mode (up to 400KHz).

7.2.45 Close-Loop Fan Control RPM mode Register

Location : Index 63h

Type : Read/Write

Power on default value : 00h

BIT	7	6	5	4	3	2	1	0
NAME	RSV		TwoDimension	RSV		RPM_HIGH_EN	RSV	
FUNC.	**TwoDimension :** Close_Loop Fan Control Enable Bit5 : 1 indicated the FAN1 group enables Close-Loop Fan Control RPM mode **RPM_HIGH_EN :** Changing default unit of all RPM setting from 50 RPMs to 100 RPMs. It benefits to control ultra high RPM fan Bit2 : 1 indicated the FAN1 group support ultra high RPM fan							

7.2.46 Temperature to Fan mapping Relationships Register

Location : Index 64h

Type : Read/Write

Power on default value : 00h

BIT	7	6	5	4	3	2	1	0
NAME	RSV			Temp2FanSelect	RSV			Temp1FanSelect

FUNC.	**Temp2FanSelect ,** **Temp1FanSelect :** Enable FANCTL1 Smart Fan. 0 = FANCTL has no relation with this temperature source. FANCTL is controlled by Manual mode. (Default) 1 = Applies SmartFan control for SMART FAN™ IV on FANCTL and this temperature.

7.2.47 Temperature to Fan mapping Relationships Register

Location : Index 65h

Type : Read/Write

Power on default value : 00h

BIT	7	6	5	4	3	2	1	0
NAME	**RSV**							**Temp3FanSelect**
FUNC.	**Temp3FanSelect :** Enable FANCTL1 Smart Fan. 0 = FANCTL has no relation with this temperature source. FANCTL is controlled by Manual mode. (Default) 1 = Applies SmartFan control for SMART FAN™ IV on FANCTL and this temperature.							

7.2.48 Fan Control Configuration Register 1

Location : Index 66h

Type : Read/Write

Power on default value : 00h

BIT	7	6	5	4	3	2	1	0
NAME	**Temp2_Share_En**	**Temp2_Share_Sel**			**Temp1_Share_En**	**Temp1_Share_Sel**		
FUNC.	**Temp2_Share_En :** Enable temperature2 sharing table function. **Temp2_Share_Sel :** Select which temperature2 source could share control table in SMART FAN™ IV **Temp1_Share_En :** Enable temperature1 sharing table function. **Temp1_Share_Sel :** Select which temperature1 source could share control table in SMART FAN™ IV Refer to the Sharing Table.							

Sharing Table.

BIT [2-0]	Share_Sel Condition
000_{BIN}	Mapping to Remote 1 temperature.
001_{BIN}	Mapping to Remote 2 temperature.
011_{BIN}	Mapping to Local temperature.
110_{BIN}	Mapping to Programmable temperature 1.

111_{BIN}	Mapping to Programmable temperature 2.

7.2.49 Fan Control Configuration Register 2

Location : Index 67h

Type : Read/Write

Power on default value : 00h

BIT	7	6	5	4	3	2	1	0
NAME	RSV				Temp3_Share_En	Temp3_Share_Sel		
FUNC.	**Temp3_Share_En :** Enable temperature3 sharing table function. **Temp3_Share_Sel :** Select which temperature3 source could share control table in SMART FAN™ IV Refer to the Sharing Table.							

7.2.50 Fan Control Configuration Register 3

Location : Index 68h

Type : Read/Write

Power on default value : 00h

BIT	7	6	5	4	3	2	1	0
NAME	RSV	Temp2_Source_Sel			RSV	Temp1_Source_Sel		
FUNC.	**Temp2_Source_Sel :** Temperature 2 source selection. **Temp1_Source_Sel :** Temperature 1 source selection. Refer to the Source Table.							

Source Table:

BIT [2-0]	Source Condition
000_{BIN}	Mapping to Remote 1 temperature.
001_{BIN}	Mapping to Remote 2 temperature.
011_{BIN}	Mapping to Local temperature.
110_{BIN}	Mapping to Programmable temperature 1.
111_{BIN}	Mapping to Programmable temperature 2.

7.2.51 Fan Control Configuration Register 4

Location : Index 69h

Type : Read/Write

Power on default value : 00h

BIT	7	6	5	4	3	2	1	0
NAME	RSV					Temp3_Source_Sel		
FUNC.	**Temp3_Source_Sel :** Temperature 3 source selection. Refer to the Source Table.							

7.2.52 Fan 1 Target Register

Location : Index 6Ah

Type : Read only

Power on default value : 8Ch

BIT	7	6	5	4	3	2	1	0
NAME	Fan1_Target							
FUNC.	**Fan1_Target :** RPM mode FANCTL1 Target Register							

7.2.53 Close-Loop Fan Control RPM Mode Tolerance Register

Location : Index 6Dh

Type : Read/Write

Power on default value : 0Ah

BIT	7	6	5	4	3	2	1	0
NAME	RSV					Generic_Tol_RPM		
FUNC.	**Generic_Tol_RPM :** Tolerance of RPM mode, unit 50 RPM.							

7.2.54 FANCTL Step Up Time Register

Location : Index 6Eh

Type : Read/Write

Power on default value : 0Ah

BIT	7	6	5	4	3	2	1	0
NAME	UpTime							
FUNC.	**UpTime :** In SMART FAN™ IV mode, this register determines the amount of time FANOUT takes to increase its value by one step. The units are intervals of 0.1 second. The default time is 1 second.							

7.2.55 FANCTL Step Down Time Register

Location : Index 6Fh

Type : Read/Write

Power on default value : 0Ah

BIT	7	6	5	4	3	2	1	0
NAME	DownTime							
FUNC.	**DownTime :** In SMART FAN™ IV mode, this register determines the amount of time FANOUT takes to decrease its value by one step. The units are intervals of 0.1 second. The default time is 1 second.							

7.2.56 Default Fan Speed Register

Location : Index 70h

Type : Read/Write

Power on default value : 7Fh

BIT	7	6	5	4	3	2	1	0
NAME	DefaultFanSpeed							
FUNC.	**DefaultFanSpeed :** (Default Fan Speed at Power-on). Specifies the fan duty at next power on.							

7.2.57 FANCTL1 PWM Prescalar Register

Location : Index 71h

Type : Read/Write

Power on default value : 84h

BIT	7	6	5	4	3	2	1	0
NAME	CLKSEL	Divisor[6:0]						
FUNC.	**CLKSEL :** Clock source select. **Divisor :** Clock frequency Divisor. Refer the Divisor table.							

The clock source selected by CLKSEL will be divided by the divisor and used as a fan PWM output frequency.

If CLKSEL equals **1**, then the output clock is simply equal to **125/ (Divisor[6:0]+1) KHz**

MappedDivisor depends on **Divisor[6:0]** and is described in the table below.

Divisor[6:0]	Mapped Divisor	Output Frequency	Divisor[6:0]	Mapped Divisor	Output Frequency
0000000	1	125KHz			
0000001	2	62.5KHz			
0000010	3	41.6KHz	.....		
0000011	4	31.2KHz			
0000100	5	25KHz	**0001111**	16	7.8KHz
0000101	6	20.8KHz	**0011111**	32	3.9KHz
0000110	7	17.8KHz	**0111111**	64	1.9KHz
0000111	8	15.6KHz	**1111111**	128	976Hz

If CLKSEL equals **0**, then the output clock is simply equal to **1000/ Mapped Divisor Hz**

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	1000Hz	**1000**	**12**	83Hz
0001	2	500Hz	**1001**	**16**	62.5Hz
0010	3	333Hz	**1010**	**32**	31.25Hz
0011	4	250Hz	**1011**	**64**	15.6Hz
0100	5	200Hz	**1100**	**128**	7.8Hz
0101	6	166Hz	**1101**	**256**	3.9Hz
0110	7	142Hz	**1110**	**512**	1.9Hz
0111	8	125Hz	**1111**	**1024**	0.97Hz

7.2.58 Temperature1 Hysteresis Register

Location : Index 74h

Type : Read/Write

Power on default value : 53h

BIT	7	6	5	4	3	2	1	0
NAME	RSV	Criti_HysT1			RSV	Oper_HysT1		
FUNC.	**Criti_HysT1 :** Hysteresis value of SMART FAN™ IV Critical Temperature **Oper_HysT1 :** Hysteresis value of SMART FAN™ IV Operating Temperature							

7.2.59 Temperature 2 Hysteresis Register

Location : Index 75h

Type : Read/Write

Power on default value : 53h

BIT	7	6	5	4	3	2	1	0
NAME	RSV	Criti_HysT2			RSV	Oper_HysT2		
FUNC.	**Criti_HysT2 :** Hysteresis value of SMART FAN™ IV Critical Temperature **Oper_HysT2 :** Hysteresis value of SMART FAN™ IV Operating Temperature							

7.2.60 Temperature 3 Hysteresis Register

Location : Index 76h

Type : Read/Write

Power on default value : 53h

BIT	7	6	5	4	3	2	1	0
NAME	RSV	Criti_HysT3			RSV	Oper_HysT3		
FUNC.	**Criti_HysT3 :** Hysteresis value of SMART FAN™ IV Critical Temperature **Oper_HysT3 :** Hysteresis value of SMART FAN™ IV Operating Temperature							

7.2.61 FANCTL Start Duty Cycle Register

Location : Index 77h

Type : Read/Write

Power on default value :30h

BIT	7	6	5	4	3	2	1	0
NAME	StartDutyCycle							
FUNC.	**StartDutyCycle :** control the FANCTL1 fan output start-up value.							

7.2.62 FANCTL Stop Time Register

Location : Index 78h

Type : Read/Write

Power on default value : FFh

BIT	7	6	5	4	3	2	1	0
NAME	StopTime							
FUNC.	**StopTime :** control the FANCTL1 fan stop time. Unit in 0.1sec. Ranges from 0.1sec to 25.5sec. If set to 0, the fan will never stop.							

7.2.63 NonStop Enable Register

Location : Index 79h

Type : Read/Write

Power on default value : 00h

BIT	7	6	5	4	3	2	1	0
NAME	RSV							NonStop_Fan1
FUNC.	**NonStop_FAN1 :** 1 indicates Enable the FANCTL1 NonStop function							

7.2.64 SMART FAN™ IV Temperature and PWM Registers Register

Location : Table 1 Address 80h ~ 88h

Location : Table 2 Address 90h ~ 98h

Location : Table 3 Address A0h ~ A8h

Type : Read/Write

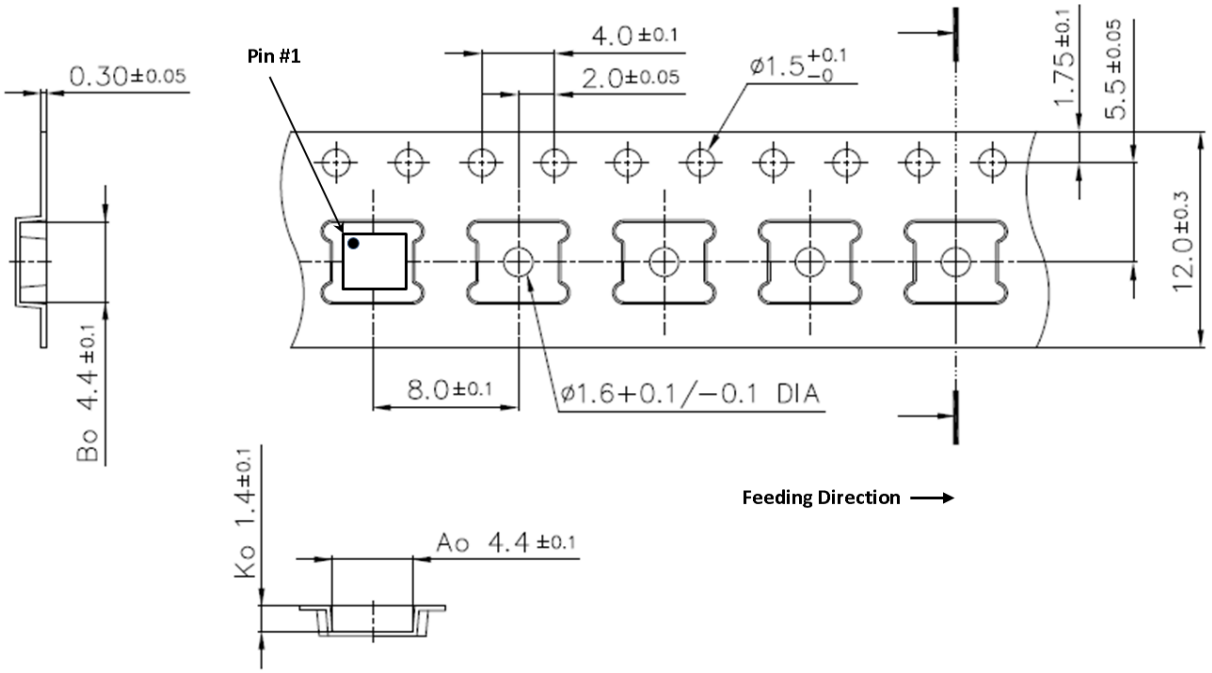
Power on default value: refer to below tables

TABLE	NAME	ADDRESS	DEFAULT	TYPE
Table1	Transition Point : **T1**	80_{HEX}	19_{HEX}	Read/Write
	Transition Point : **T2**	81_{HEX}	23_{HEX}	Read/Write
	Transition Point : **T3**	82_{HEX}	23_{HEX}	Read/Write
	Transition Point : **T4**	83_{HEX}	37_{HEX}	Read/Write
	Critical Point	84_{HEX}	$3C_{HEX}$	Read/Write
	Y-axis Transition Point : **PWM1**	85_{HEX}	$8C_{HEX}$	Read/Write
	Y-axis Transition Point : **PWM2**	86_{HEX}	$8C_{HEX}$	Read/Write
	Y-axis Transition Point : **PWM3**	87_{HEX}	$C8_{HEX}$	Read/Write
	Y-axis Transition Point : **PWM4**	88_{HEX}	$E6_{HEX}$	Read/Write
Table2	Transition Point : **T1**	90_{HEX}	19_{HEX}	Read/Write
	Transition Point : **T2**	91_{HEX}	23_{HEX}	Read/Write
	Transition Point : **T3**	92_{HEX}	23_{HEX}	Read/Write

TABLE	NAME	ADDRESS	DEFAULT	TYPE
	Transition Point : **T4**	93_{HEX}	37 HEX	Read/Write
	Critical Point	94_{HEX}	3C HEX	Read/Write
	Y-axis Transition Point : **PWM1**	95_{HEX}	8C HEX	Read/Write
	Y-axis Transition Point : **PWM2**	96_{HEX}	8C HEX	Read/Write
	Y-axis Transition Point : **PWM3**	97_{HEX}	C8 HEX	Read/Write
	Y-axis Transition Point : **PWM4**	98_{HEX}	E6 HEX	Read/Write
	Transition Point : **T1**	$A0_{HEX}$	19 HEX	Read/Write
	Transition Point : **T2**	$A1_{HEX}$	23 HEX	Read/Write
	Transition Point : **T3**	$A2_{HEX}$	23 HEX	Read/Write
	Transition Point : **T4**	$A3_{HEX}$	37 HEX	Read/Write

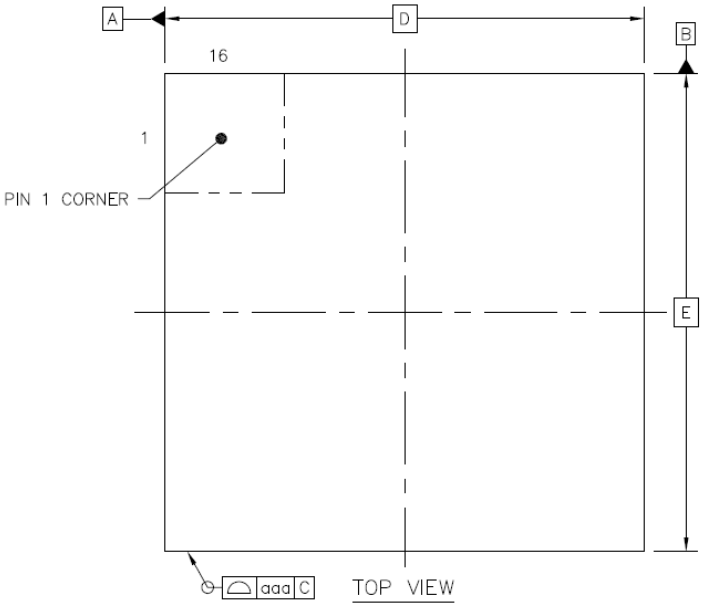
Table3

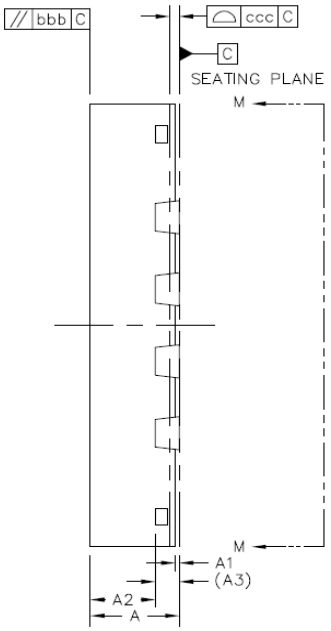
12. TAPING SPECIFICATION

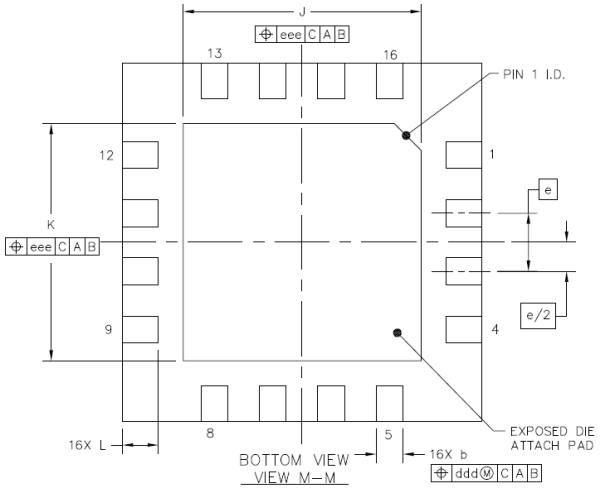


13. PACKAGE DRAWING AND DIMENSIONS

QFN16 4x4 MM2







Unit:mm

SYMBOL	Min	Nom	Max
A	0.7	0.75	0.8
A1	0	0.02	0.05
A3		0.2 REF	
b	0.25	0.30	0.35
D		4.00 BSC	
E		4.00 BSC	
e		0.65 BSC	
J	2.4	2.55	2.65
K	2.4	2.55	2.65
L	0.35	0.4	0.45
aaa		0.1	
bbb		0.1	
ccc		0.08	
ddd		0.1	
eee		0.1	

14. REVISION HISTORY

VERSION	DATE	PAGE	DESCRIPTION
1.0	07/2012	38	Public Release
1.1	01/2015		Add description of the self-programming EEPROM function Add Programing Temperature Registers
1.2	06/2015	2	Add the operating supply current spec
1.21	09/2015	1-2	Modified some typos
1.22	03/2017	34	Add Non Stop Enable register
1.23	05/2018	28	Control the fan speed by manual mode in I2C fast mode（up to 400KHz）.
1.3	11/2018	2	FANIN Monitoring Accuracy
		42	Add PCB layout notice
1.4	07/07/2021	45	Update package information

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