1. General Description

The ATTM01/ATTM02 are precision remote diode temperature sensors with a 2-wire System Management Bus (SMBus) serial interface. The ATTM01/ATTM02 measure: (1) Local temperature and (2) the temperature of a remote diode based transistor from Computer Processor Unit (CPU), Graphic Processor Unit (GPU) or other ASICs.

The ATTM01/ATTM02 provide two system alarms: ALERT# and OVERT#.

(1) ALERT# event occurs when any temperature goes outside the value that setup by preprogrammed HIGH and LOW temperature limit registers.

(2) OVERT# event occurs when any temperature exceeds the OVERT# programmed limit.

ATTM02 has a different SMBus address to the ATTM01. The SMBus address of the ATTM01 is 0x90 and ATTM02 is 0x94.

2. Features

- Remote and Local Temperature Sensing.
- ±1℃ Accuracy.
- Programmable HIGH/LOW Alarm Temperature Thresholds.
- ALERT# Output Supports SMBus Protocol.
- OVERT# Output Useful for System Shutdown.
- SMBus-compatible interface.
- SMBus timeout support.
- Packages: SOP-8 and MSOP-8

3. Pin Configuration/ Top Side Mark

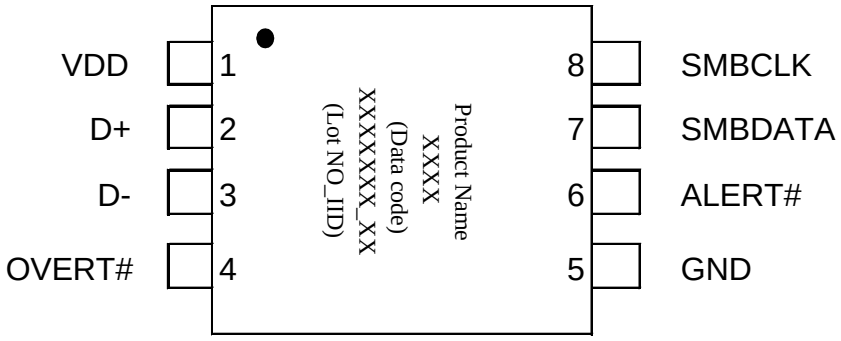


Figure1. ATTM01/ATTM02 Pin Diagram (Top View)

※ Ordering Information

Part number	Package	SMBus address	Marking
ATTM01	SOP-8	0x90	TM01
ATTM01G	SOP-8, Green	0x90	TM01G
ATTM01M	MSOP-8	0x90	TM01M
ATTM01MG	MSOP-8, Green	0x90	TM01MG
ATTM02	SOP-8	0x94	TM02
ATTM02G	SOP-8, Green	0x94	TM02G
ATTM02M	MSOP-8	0x94	TM02M
ATTM02MG	MSOP-8, Green	0x94	TM02MG

4. Pin Description

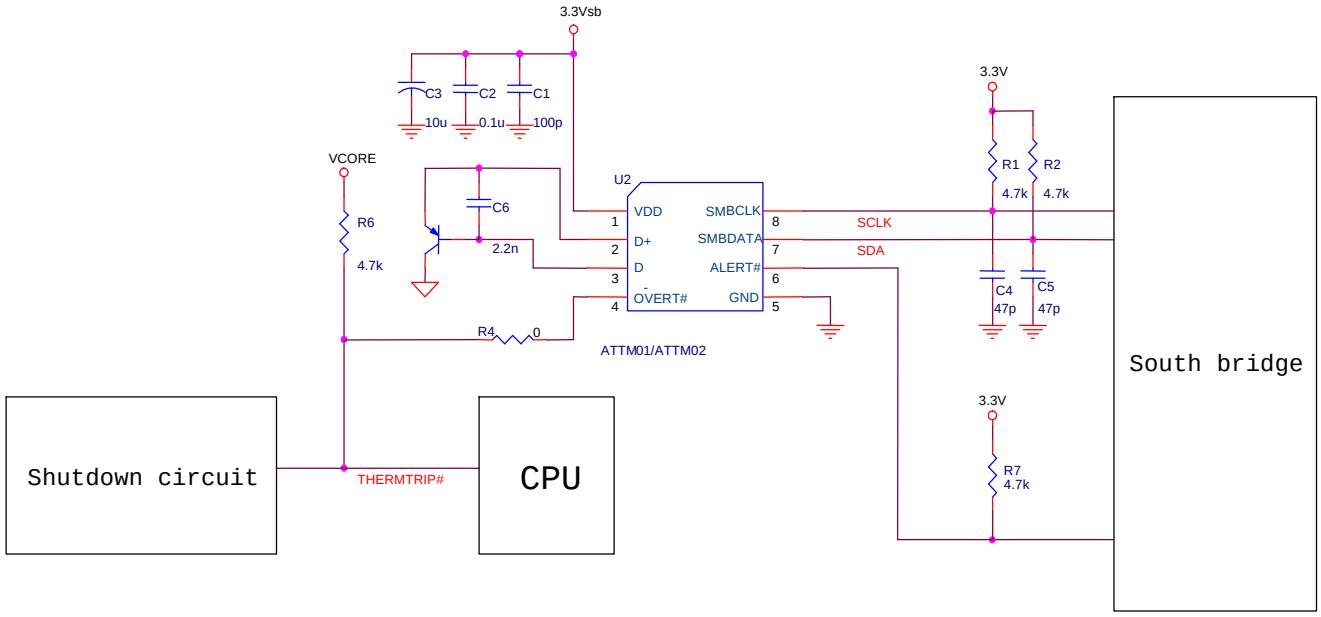
Pin Type Description

OD - Open-drain output
IN - Input pin
AIN - Analog input.

I/OD - Bi-directional with open-drain output.

Pin No.	Pin Name	I/O Type	Function
1	VDD	Power	3.3V Power Input.
2	D+	AIN	Thermal diode anode Input
3	D-	AIN	Thermal diode cathode Input.
4	OVERT#	OD	Power supply shutdown control.
5	GND	Ground	Ground pin.
6	ALERT#	OD	SMBus alert (interrupt) Output.
7	SMBDATA	I/OD	SMBus bi-directional data line.
8	SMBCLK	IN	SMBus clock Input.

■ Typical Application



6. Electrical Specifications

(These specifications apply for V_{CC} = 3.3V and T_A = +25°C, unless otherwise noted.) (Note 1)

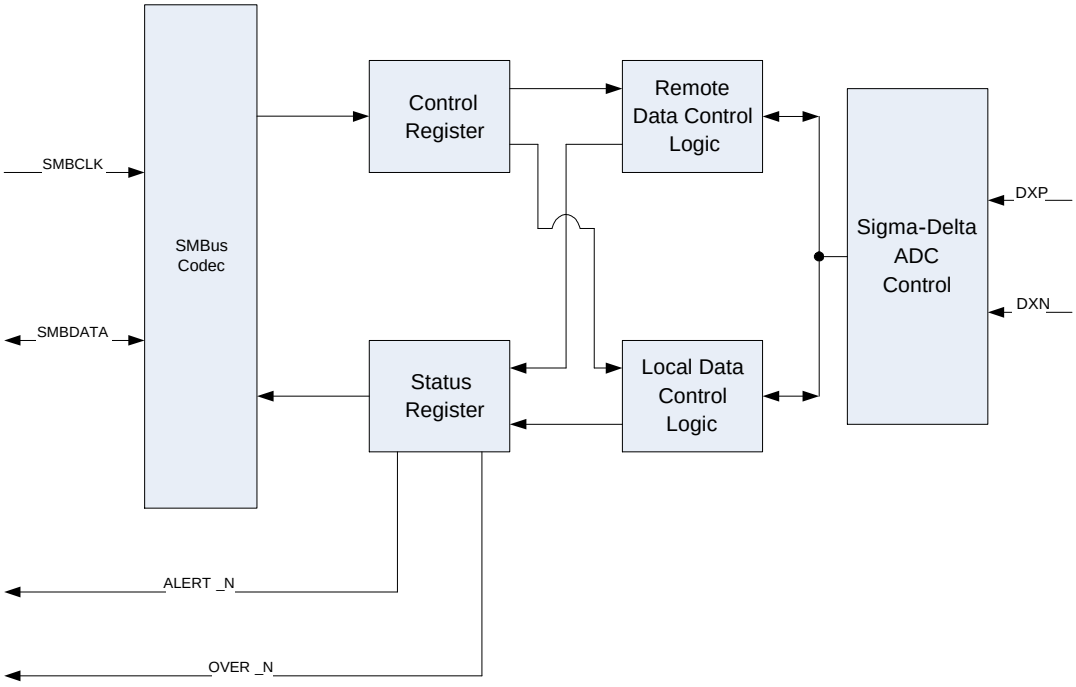
Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Supply Voltage	V_{CC}		3		3.6	V
Temperature Resolution			0.5			°C
				9		Bits
Remote Temperature Error		V_{CC} = 3.3V, T_A =+25°C to +100°C, T_{RJ} = +60°C to +100°C	-1.0		+ 1.0	°C
		V_{CC} = 3.3V, T_A =+25°C to +100°C, T_{RJ} = 0°C to +100°C	-3.0		+ 3.0	°C
		V_{CC} = 3.3V, T_A =+25°C to +100°C, T_{RJ} = 0°C to +125°C	-5.0		+ 5.0	°C
Local Temperature Error		V_{CC} = 3.3V, T_A = +60°C to +100°C	-2.0		2.0	°C
		V_{CC} = 3.3V, T_A = 0°C to +100°C	-3.0		3.0	°C
Supply Sensitivity of Temperature Error				±0.2		°C/V
UVLO Hysteresis				120		mV
UVLO Threshold		Falling edge		2.62		V
Power-On-Reset (POR) Threshold		Rising edge		2.74		V
Power-On-Reset (POR) Hysteresis				120		mV
Standby Supply Current		SMBus static		7.8		µA
Operating Current		During conversion		0.53		mA
Conversion Time	t_{CONV}	From stop bit to conversion completion	95	125	156	ms
Conversion Time Error			-25		+25	%
Remote-Diode Source Current	I_{RJ}	High level	75	100	140	µA
		Low level	7.5	10	14	
ALERT, OVERT						
Output Low Voltage		I_{SINK} = 1mA			0.4	V
		I_{SINK} = 4mA			0.6	V
Output High Leakage Current		V_{OH} = 5.5V			1	µA
SMBus-COMPATIBLE INTERFACE (SMBCLK AND SMBDATA)						
Logic Input Low Voltage	V_{IL}				0.8	V
Logic Input High Voltage	V_{IH}	V_{CC} = 3.0V	2.2			V
		V_{CC} = 5.5V	2.6			V
Input Leakage Current	I_{LEAK}	V_{IN} = GND or V_{CC}	-1		1	µA
Output Low-Sink Current	I_{SINK}	V_{OL} = 0.6V	6			mA
Input Capacitance	C_{IN}			5		pF

6. Electrical Specifications

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
SMBus-COMPATIBLE TIMING (Note 2)						
Serial Clock Frequency	f_{SMBCLK}	(Note 3)			100	kHz
Bus Free Time Between STOP and START Condition	t_{BUF}		4.7			µs
START Condition Setup Time			4.7			µs
Repeat START Condition Setup Time	$t_{SU:STA}$	90% to 90%	50			ns
START Condition Hold Time	$t_{HD:STA}$	10% of SMBDATA to 90% of SMBCLK	4			µs
STOP Condition Setup Time	$t_{SU:STO}$	90% of SMBCLK to 90% of SMBDATA	4			µs
Clock Low Period	t_{LOW}	10% to 10%	4.7			µs
Clock High Period	t_{HIGH}	90% to 90%	4			µs
Data Setup Time	$t_{HD:DAT}$	(Note 4)	250			µs
Receive SMBCLK/SMBDATA Rise Time	t_R				1	µs
Receive SMBCLK/SMBDATA Fall Time	t_F				300	ns
Pulse Width of Spike Suppressed	t_{SP}		0		60	ns
SMBus Timeout	$t_{TIMEOUT}$	SMBDATA low period for interface reset	25	37	45	ms

Note 1: All parameters tested at a single temperature. Specifications over temperature are guaranteed by design.
Note 2: Timing specifications guaranteed by design.
Note 3: The serial interface resets when SMBCLK is low for more than $t_{TIMEOUT}$.
Note 4: A transition must internally provide at least a hold time to bridge the undefined region (300ns max) of SMBCLK's falling edge.

7. Hardware Monitor Block



Hardware Monitor Interface

This chip is using the 2-wire SMBus serial interface to control the hardware monitor function. The major function of the hardware monitor is monitored the remote diode and local diode temperature. It also using the trimmed mechanism to control the accuracy of the temperature sensor under ± 1 ℃. It also uses the 2-wire SMBus serial interface. The two interrupt outputs ALERT# and OVER# are active low at default state and can change these outputs to active high when set bit 1 of register address 8' h31 to logic one. The slave address of SMBus can select by initial state of ALERT# when power on or access the command index 8' h42. **This chip provides two slave address 7'h1001000 and 7'h1001010 to avoid conflict with other devices.**

8. SMBus Protocol

In this chip it supports the write byte and read byte mode protocol. The following is SMBus read/write data format.

Write Byte Format:

START	Slave Address	WR	ACK	COMMAND	ACK	DATA	ACK	STOP
1 bit	7 bits	1 bit	1 bit	8 bits	1 bit	8 bits	1 bit	1 bit

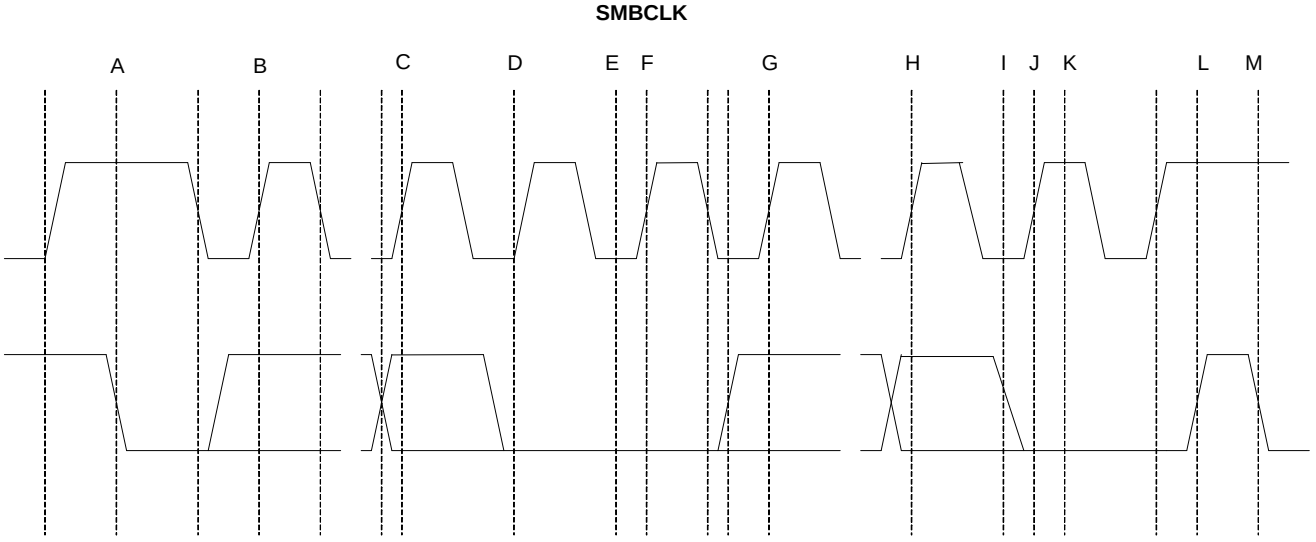
The COMMAND Byte is selects that register you are writing to. The DATA Byte is data goes into the register set by the command byte (to set thresholds, configuration, and update rate).

Read Byte Format:

S	Address	WR	ACK	COMMAND	ACK	S	Address1	RD	ACK	DATA	NAK	STOP
1 bit	7 bits	1 bit	1 bit	8 bits	1 bit	1 bit	8 bits	1 bit	1 bit	8 bits	1 bit	1 bit

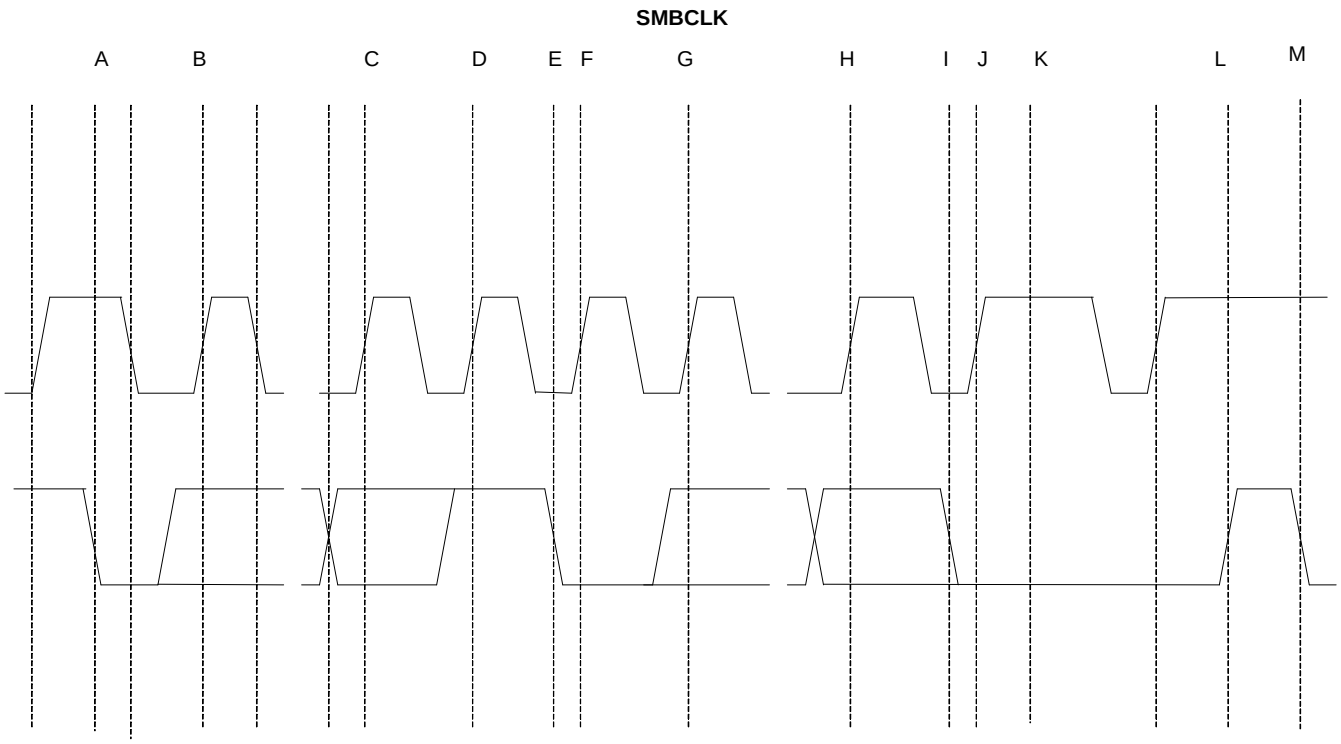
The S denotes Start Bit. Address represents slave address. The COMMAND Byte is selects that register you are reading from. The Address1 is due to change in data flow direction. The DATA Byte is reads from the register set by the command byte. The in above table the red color denotes Slaver transmission.

SMBus Write Timing Diagram:



A = START CONDITION
B = MSB OF ADDRESS CLCOKED INTO SLAVE
C = LSB OF ADDRESS CLOCKED INTO SLAVE
D = R/W_ BIT CLOCKED INTO SLAVE
E = SLAVE PULL SMBDATA BUS LOW
F = ACKNOWLEDGE BIT CLOCKED INTO MASTER
G = MSB OF DATA CLOCKED INTO SLAVE
H = LSB OF DATA CLOCKED INTO SLAVE
I = SLAVE PULLS SMBDATA BUS LOW
J = ACKNOWLEDGE BIT CLOCKED INTO MASTER
K = ACKNOWLEDGE CLEAR PULSE
L = STOP CONDITION DATA EXECUTED BY SLAVE
M = NEW START CONDITION

SMBus Read Timing Diagram:



A = START CONDITION
B = MSB OF ADDRESS CLOCKED INTO SLAVE
C = LSB OF ADDRESS CLOCKED INTO SLAVE
D = R/W_ BIT CLOCKED INTO SLAVE
E = SLAVE PULLS SMBDATA BUS LOW
F = ACKNOWLEDGE BIT CLOCKED INTO MASTER

G = MSB OF DATA CLOCKED INTO MASTER
H = LSB OF DATA CLOCKED INTO MASTER
I = MASTER PULLS DATA BUS INTO LOW
J = ACKNOWLEDGE BIT CLOCKED INTO SLAVE
K = ACKNOWLEDGE CLEAR PULSE
L = STOP CONDITION, DATA EXECUTED BY SLAVE
M = NEW START CONDITION

9. Hardware Monitor Register

The following registers define the temperature sensor control and status registers, data registers and SMBus slave address register.

9.1 Local Diode Higher Byte Temperature Register, Access Address: "Command Index = 0h"

Field	Type	Position	Bits	I	Function
ADCLOCA_DATA	RO	[7:0]	8	0	Local diode higher byte temperature data. Bit 7 denotes the sign bit. The LSB represents 1℃.

9.2 Remote Diode Higher Byte Temperature Register, Access Address: "Command Index = 1h"

Field	Type	Position	Bits	I	Function
ADCREMOTE_DATA	RO	[7:0]	8	0	Remote diode higher byte temperature data. The bit 7 denotes the sign bit. The LSB represents the 1 ℃.

9.3 Temperature Sensor Status Register, Access Address: "Command Index = 2h"

Field	Type	Position	Bits	I	Function
BUSY	RO	[7]	1	0	ADC converting data.
LTHOT_REG	RC	[6]	1	0	The ADC measure the temperature of local diode that exceed the alerting high limit. When software reading this register it will reset to zero if active condition no more satisfy.
LTCOOL_REG	RC	[5]	1	0	The ADC measure the temperature of local diode that below the alerting low limit. When software reading this register it will reset to zero if active condition no more satisfy.
RTHOT_REG	RC	[4]	1	0	The ADC measure the temperature of remote diode that exceed the alerting high limit. When software reading this register it will reset to zero if active condition no more satisfy.
RTCOOL_REG	RC	[3]	1	0	The ADC measure the temperature of remote diode that below the alerting low limit. When software reading this register it will reset to zero if active condition no more satisfy.
DIODE_OPEN	RO	[2]	1	0	The ADC detects the DXP and DXN pins disconnect to remote diode.
RCRITI_REG	RC	[1]	1	0	The ADC measure the temperature of remote diode that exceed the remote diode critical limit. When software reading this register it will reset to zero if active condition no more satisfy.
LCRITI_REG	RC	[0]	1	0	The ADC measure the temperature of local diode that exceed the local diode critical limit. When software reading is register it will reset to zero if active condition no more satisfy.

9.4 ADC Configuration Register, Access Address: "Command Index = 3h"

Field	Type	Position	Bits	I	Function
ALERT_MASK	RO	[7]	1	0	ALERT# mask. When set to "1" ALERT# interrupts are masked.
STOP	RO	[6]	1	0	When set to "1" the ADC will be terminated.
Reserved	NA	[5]	1	0	Reserved. Not implemented.
CRITI_MASK	RO	[4]	1	0	OVER# mask. When set to "1" OVER# interrupts is masked.
Reserved	NA	[3:1]	3	0	Reserved. Not implemented.
FAULT_QUEUE	RO	[0]	1	0	When set to "1" denotes three consecutive remote temperature measurement outside the Alerting, Critical limit.

9.5 ADC Conversion Rate Register, Access Address: "Command Index = 4h"

Field	Type	Position	Bits	I	Function
Reserved	NA	[7:5]	3	0	Reserved. Not implemented.
UPDATE_RATE	RO	[4:0]	5	0	ADC measure temperature value rate.

9.6 Local Diode Alerting High Limit Register, Access Address: "Command Index = 5h"

Field	Type	Position	Bits	I	Function
LALERT_HIGH	RO	[7:0]	8	8'h50	Local diode alerting high limit register. The default is set to 80 °C. The LSB denotes 1 °C.

9.7 Local Diode Alerting Low Limit Register, Access Address: "Command Index = 6h"

Field	Type	Position	Bits	I	Function
LALERT_LOW	RO	[7:0]	8	0	Local diode alerting low limit register. The default is set to 0 °C. The LSB denotes 1 °C.

9.8 Remote Diode Alerting High Limit Register, Access Address: "Command Index = 7h"

Field	Type	Position	Bits	I	Function
RALERT_HIGH	RO	[7:0]	8	8'h50	Remote diode alerting high limit register. The default is set to 80°C. The LSB denotes 1 °C

9.9 Remote Diode Alerting Low Limit Register, Access Address: "Command Index = 8h"

Field	Type	Position	Bits	I	Function
RLAERT_LOW	RO	[7:0]		0	Remote diode alerting low limit. The default value is set to 0 °C. The LSB represents 1 °C.

9.10 Temperature sensor Configuration Register, Access Address: "Command Index = 9h"

Field	Type	Position	Bits	I	Function
ALERT_MASK	WO	[7]	1	0	When set to "1" ALERT# interrupt is masked.
STOP	WO	[6]	1	0	When set to "1" then the ADC will be terminated.
Reserved	NA	[5]	1	0	Reserved. Not implemented.
CRITI_MASK	WO	[4]	1	0	When set to "1" the Remote/Local diodes exceed the critical set point will no activated the OVER# pin..
Reserved	NA	[3:0]	4	0	Reserved. Not implemented.

9.11 ADC Conversion Rate Register, Access Address: "Command Index = Ah"

Field	Type	Position	Bits	I	Function
Reserved	N/A	[7:4]	4	0	Reserved. Not implemented.
CONVERSIO_RATE	WO	[3:0]	4	4'h8	Control the ADC value update to SMBus register. The variable rate control can be used to reduce supply current in portable equipment application. 4'h8: conversion rate is 16 Hz (default value), 4'h7: conversion rate is 8 Hz, 4'h6: conversion rate is 4 Hz, 4'h5: conversion rate is 2 Hz, 4'h4: conversion rate is 1 Hz, 4'h3: conversion rate is 0.5 Hz, 4'h2: conversion rate is 0.25 Hz, 4'h1: conversion rate is 0.125 Hz, 4'h0: conversion rate is 0.0625 Hz, other values are reserved.

9.12 Local Diode Alerting High Limit Register, Access Address: "Command Index = Bh"

Field	Type	Position	Bits	I	Function
LALERT_HIGH	WO	[7:0]	8	8'h50	Setting the local diode alerting high limit register. The default value is 80 °C and the LSB denotes 1 °C.

9.13 Local Diode Alerting Low Limit Register, Access Address: "Command Index = Ch"

Field	Type	Position	Bits	I	Function
LAERT_LOW	WO	[7:0]	8	0	Setting the local diode alerting low limit register. The default value is 0 °C and the LSB represents 1 °C.

9.14 Remote Diode Alerting High Limit Temperature Register, Access Address: "Command Index = Dh"

Field	Type	Position	Bits	I	Function
RHIGH_DATA	W/O	[7:0]	8	8'h50	Host set the remote diode high limit temperature value. The default value set to 80 °C and LSB denotes 1 °C.

9.15 Remote Diode Alerting Low Limit Temperature Register, Access Address: "Command Index = Eh"

Field	Type	Position	Bits	I	Function
RLOW_DATA	W/O	[7:0]	8	0	Host set the remote diode low limit temperature value. The default value is 0 ℃ and LSB represents 1 ℃.

9.16 One Shot Register, Access Address: "Command Index = Fh"

Field	Type	Position	Bits	I	Function
Reserved	NA	[7:1]	7	0	Reserved. Not implemented.
ONESHOT_ADC	WO	[0]	1	0	When want to reduce the supply current it can set bit 6 of register 9 configuration register to "1" and also set this bit to "1" and then write to "0", i.e., create a one shot pulse. The ADC will be ceased operation after measure one cycle per each remote/local diode.

9.17 Remote Diode Lower Byte Temperature Register, Access Address: "Command Index = 10h"

Field	Type	Position	Bits	I	Function
Reserved	NA	[7:1]	7	0	Reserved. Not implemented.
ADCREMOTE_DATA	RO	[0]	1	0	The remote diode lower byte temperature data. The LSB denotes 0.5 ℃.

9.18 Remote Diode Temperature Offset Register, Access Address: "Command Index = 11h"

Field	Type	Position	Bits	I	Function
ROFFSET_DATA	W/R	[7:0]	8	0	Remote diode temperature offset register to adjust the decimated filter because of the PCB placement, routing, and different thermal diode. Two's complement format.

9.19 Remote Diode Critical Temperature Limit Register, Access Address: "Command Index = 19h"

Field	Type	Position	Bits	I	Function
RCRITI_DATA	W/R	[7:0]	8	8'h6E	Remote diode critical temperature registers. The default value is 110 ℃ and the LSB denotes 1 ℃.

9.20 Local Diode Critical Temperature Limit Register, Access Address: "Command Index = 20h"

Field	Type	Position	Bits	I	Function
LCRITI_DATA	W/R	[7:0]	8	8'h55	Local diode critical temperatures register. The default is 85 ℃ and the LSB denotes 1 ℃.

9.21 Remote Diode Critical Hysteresis Temperature Register, Access Address: "Command Index = 21h"

Field	Type	Position	Bits	I	Function
Reserved	NA	[7:5]	3	0	Reserved. Not implement.
CRITI_HYSTE	W/R	[4:0]	5	8'hA	Hysteresis the remote diode temperature registers. The default value is 10 ℃ and LSB denotes 1 ℃. When temperature exceed the critical temperature limit the OVER# pin will be activate and the OVER# pin will be deactivate when temperature below the critical temperature limit minus this register value (CRITI_HYSTE).

9.22 Local Diode Lower Byte Temperature Register, Access Address: "Command Index = 30h"

Field	Type	Position	Bits	I	Function
Reserved	NA	[7:1]	7	0	Reserved. Not implemented.
ADCLOCAL_DATA	RO	[0]	1	0	The local diode temperature data. The LSB denotes 0.5 ℃.

9.23 Thermal Sensor Control Register, Access Address: "Command Index = 31h"

Field	Type	Position	Bits	I	Function
CLEAR_REG	WR	[7]	1	0	Clear the ADC data.
EN_DIRECT	WR	[5]	1	0	Enable the local diode temperature data without moving average.
EN_RADC_DIR	WR	[4]	1	0	Enable the remote diode temperature data without moving average.
ANA_MODE	WR	[3]	1	0	When set to "1" then the internal clock and band gap voltage can output from ALERT# and OVER#, respectively.
EN_ADCLOCAL	WR	[2]	1	1	Enable the ADC measure the local diode.
INT_POLARITY	WR	[1]	1	1	Change the polarity of ALERT# and OVER#. When set to "0" these two signals change to active high signal from active low.
EN_ADCREMOTE	WR	[0]	1	1	Enable the ADC measure the remote diode.

9.24 Thermal Sensor Status Register, Access Address: "Command Index = 32h"

Field	Type	Position	Bits	I	Function
UVLO	RO	[7]	1	1	When the voltage drop to 2.62V then this signal will be activated. Because when the voltage below 2.62V the ADC can not normal operation.
DIODE_SHORT	RO	[6]	1	0	The ADC analog circuit detects the DXP and DXN pins are short together.
Reserved	NA	[5:0]	6	0	Reserved. Not implemented.

9.25 SMBus Control Register, Access Address: "Command Index = 42h"

Field	Type	Position	Bits	I	Function
ADDR_SEL	WR	[7]	1	0	Select SMBus slave address. 0: slave address is 7'h48, 1: slave address is 7'h4A. The SMBus slave address can determine from this register bit and also can pull up or pull down the ALERT# pin. When pull up ALERT# pin the slave address is 7'h48, otherwise it is 7'h4A.
Reserved	NA	[6:4]	3	0	Reserved. Not implemented.
SOFT_RESET	WR	[3]	1	0	Software reset the control logic.
Reserved	NA	[2:1]	2	2'b10	Reserved. Not implemented. Bit [2] always one.
FREE_RUN_MODE	WR	[0]	1	0	ADC free run mode, i.e., the ADC operation does not restrict by conversion rate.

10. Hardware Monitor Programming Guide

If want to this chip fully operation on PCB board the first step it need setting the remote and local diode offset. This offset can eliminate the PCB trace, binding wire loading. When software setting the offset register to reduce side effect of PCB trace to minimum then the temperature data accuracy is 0.5 ℃.

Setting the bit 5, bit4 of Thermal Sensor Control Register can enable or disable the digital filter. When these bit set to logic one then the digital filter will be turned on, otherwise, these digital filter will be turned off.

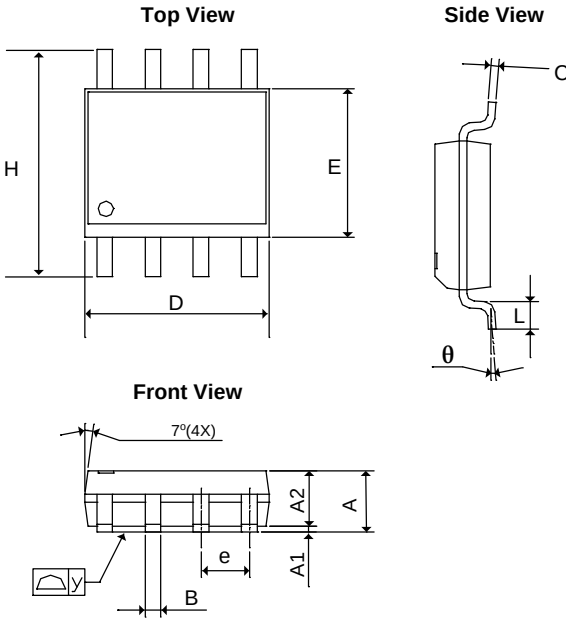
In this chip has a parity check mechanism to avoid the software reading remote or local temperature data and the ADC converting temperature into this register. In other words, when the software reading the temperature data (register 8'h0, 8'h1, 8'h10, 8'h30) and at the same time the ADC want converting temperature data to register 8'h0, 8'h1, 8'h10, or 8'h30 then the parity check mechanism will halt the ADC converting temperature data to these registers before software read finish these register. In order to make parity check mechanism can work well when read the temperature data it need read the high byte temperature data at first and continue read the low byte temperature data, i.e., read the temperature data register the first need read register 8'h0 or 8'h1 and consecutive read register 8'h30 or 8'h10.

When the software want to reduce the supply current it can enable the one shot mode and this mode operation only at standby mode, i.e., bit 6 of Configuration register set to "1". The software need set the bit 1 of register 8'hF address to "1" and consecutive set this bit to "1" to generate one pulse signal.

The bit 7 (BUSY) of status register will not effect the reading temperature data. Because of this bits only show that ADC converting data.

11. Package Dimension

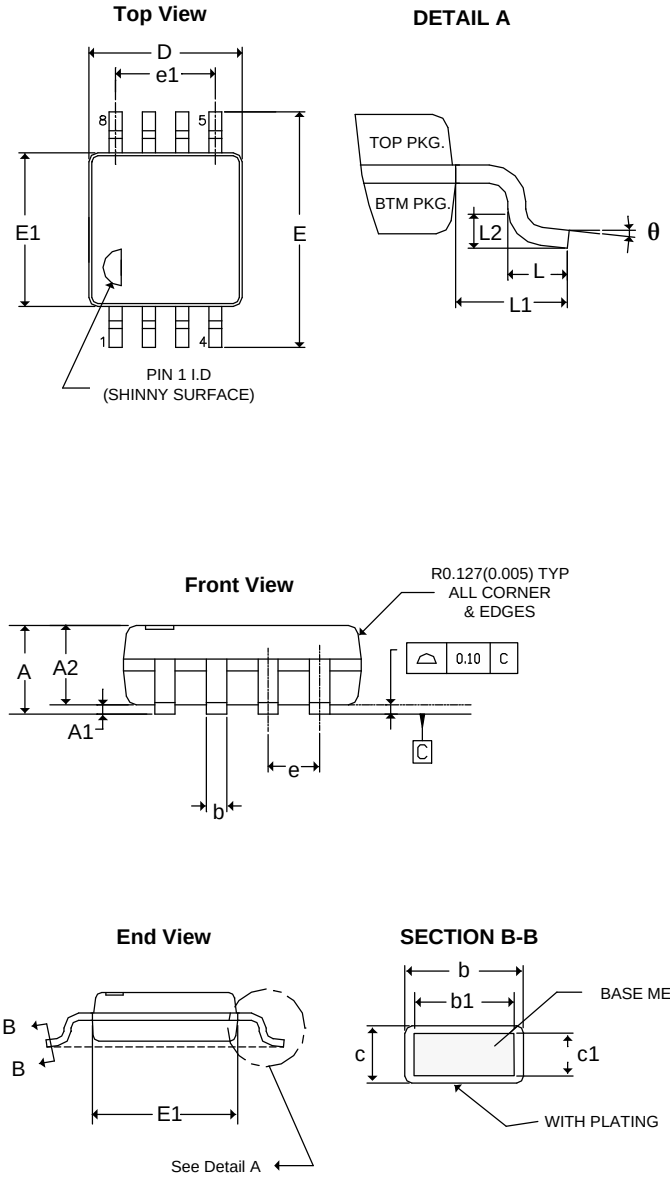
SOP-8



SYMBOLS	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.05315	0.0689
A_1	0.10	0.30	0.00394	0.01181
A2	1.473 REF		0.05799 REF	
B	0.33	0.51	0.01299	0.02008
C	0.19	0.25	0.00748	0.00984
D	4.80	5.33	0.18898	0.20984
E	3.80	4.00	0.14961	0.15748
e	1.27 BSC		0.05000 BSC	
L	0.40	1.27	0.01575	0.05000
H	5.80	6.30	0.22835	0.24803
y	-	0.10	-	0.00394
q	0^o	8^o	0^o	8^o

11. Package Dimension

MSOP-8



SYMBOLS	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	-	1.07	-	0.04197
A_1	0.05	0.20	0.002	0.008
A2	0.81	0.92	0.032	0.036
b	0.28	0.38	0.011	0.015
b1	0.28	0.33	0.011	0.013
c	0.13	0.23	0.005	0.009
c1	0.13	0.17	0.005	0.006
D	2.90	3.10	0.114	0.122
E	4.77	4.98	0.188	0.196
E1	2.90	3.10	0.114	0.122
e	0.65 TYP		0.0255 TYP	
e1	1.95 TYP		0.0767 TYP	
L	0.406	0.686	0.01598	0.02701
L1	0.94 REF		0.037 REF	
L2	0.254 TYP		0.010 TYP	
q	0^o	8^o	0^o	8^o



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Document: ATT-DSATTM01/ATTM02-B.01

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