I²C-Bus Temperature Sensors

Small, accurate, low-cost sensors for advanced temperature regulation

ACCURATE PERFORMANCE IN A PROVEN FORMAT

NXP temperature sensors use the familiar I²C-bus/SMBus format* to deliver highly accurate temperature monitoring with low power consumption in a wide variety of applications. Each device is pin-for-pin compatible with industry-standard sensors and combines a high level of precision with programmable features that help increase design flexibility.

LOCAL-ONLY TEMPERATURE SENSORS

Our local-only temperature sensors produce highly accurate digital readings of the ambient temperature and can be used to trigger interrupt, shut-down, or overtemperature alarms. They are suited for use in industrial process control, notebook computers, servers, and office electronics.

- The LM75B is a local temperature sensor and thermal watchdog with an accuracy of ±2 °C
- The PCT2075, a more accurate version of the LM75B, delivers superior performance in temperature-sensitive applications
- The SE98A, designed for applications that use DDR3 RDIMM memory, complies with JEDEC JC42.4, supports SMBus Timeout and Alert, and has security lock bits
- The SE97B brings the SE98A and a 2 Kbit EEPROM serial presence detect (SPD) together in a single device

REMOTE AND LOCAL TEMPERATURE SENSORS

Our combination remote/local sensors can monitor the temperature of the thermal diode inside the CPU or the diode connected to PNP or NPN transistors, and can trigger an interrupt or alert output.

- The SA56004 sensor, designed for handheld and portable applications, includes an offset register for system calibration, dual outputs for fan control and an interrupt, built-in diode fault detection, and one-shot conversion with power optimization in shutdown mode. It is available in a small, 8-pin package with three possible pre-confi gured slave device addresses.

APPLICATIONS

System thermal management	Office electronics
Personal computer	Microprocessor
Communications equipment	Power supply
Industrial process control	Laptop
Servers	DDR3 RDIMM (SE97B and SE98A only)

*For more on the I²C-bus and SMBus, see Overview on page 9.

NXP I²C-BUS/SMBUS TEMPERATURE SENSORS

Feature	Benefit
Wide supply range (1.7 to 5.5 V)	Suitable for 3.3- or 5-V systems
Wide temperature operating range (-55 to 125 °C)	Suitable for all system thermal management
Low operating and standby power	Suitable for all applications, including battery management
Programmable temperature set points	Temperature thresholds are easy to change
Standby mode and one-shot conversion	Suitable for power-sensitive applications like laptops and handhelds
Programmable fault queue	Prevents noise-triggered temperature trips

FAMILY OVERVIEW

	Local Channels	Remote Channels	Thermal-Alarm Output*	Fan-Control Output*	Temp Range	Frequency	Accuracy (Local Sensing - typ)	Accuracy (Remote Sensing - typ)	A/D Resolution (°C/# Bits)	Supply Range (V)	Supply Current Operating (µA - typ)	Supply Current sShutdown (µA - typ)	Package(s)
LM75B	1		1		-55 to +125 °C	400 kHz	±1 °C		0.125/11	2.8-5.5	100	0.2	SO8, MSOP8, XSON8(U) and HWSON8
PCT2075	1		1		-55 to +125 °C	1000 kHz	±1 °C		0.125/11	2.7-5.5	125	<0.1	SO8, TSSOP8, HWSON8 and TSOP6
SA56004	1	1	1	1	-40 to +125 °C	400 kHz	±1 °C	±1 °C	0.125/11	3.0-3.6	500	10	SO8, MSOP8 and HVSON8
SE97B	1 with 2 kbit SPD				-40 to +125 °C	400 kHz	±0.5 °C		0.125/11	3.0-3.6	210	0.1	HWSON8
SE98A	1				-40 to +125 °C	400 kHz	±0.5 °C		0.125/11	1.7-3.6	250	0.1	HWSON8

* Open-drain output

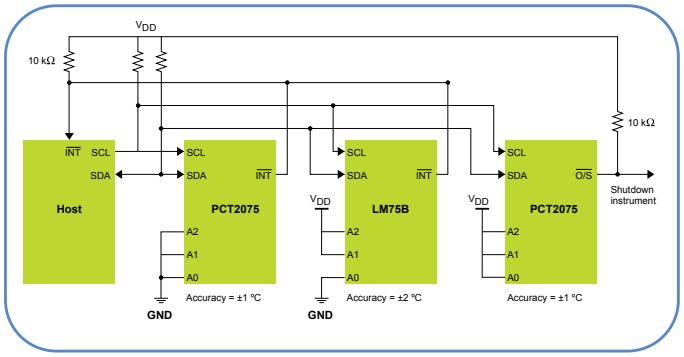
LOCAL-ONLY TEMPERATURE SENSORS

LOCAL TEMPERATURE SENSOR AND THERMAL WATCHDOG PCT2075 WITH ACCURACY OF ±1 °C

Features:

- On-chip thermal diode
- Bus: two-wire I²C-bus (1MHz Fast Mode Plus)
- Accuracy (max): ±1 °C (from -25 to 100 °C)
- Resolution: 11-bit (0.125 °C)
- Open-drain interrupt or comparator/thermostat output
- Shutdown mode and one-shot conversion capability
- Programmable temperature conversion rate (0.125 to 30 Hz)
- Shutdown/operating current (max): <0.1/400 µA
- Power-supply range: 2.7 to 5.5 V
- Temperature range: -55 to 125 °C
- Package: TSSOP(MSOP)8, SO8, XSON8U and HWSON8
- Drop-in replacement for: National LM75, Microchip TCN75, Maxim DS75, TI TMP75, Analog Devices AD7416

PCT2075/LM75B APPLICATION DIAGRAM



LOCAL TEMPERATURE SENSOR AND THERMAL WATCHDOG LM75B WITH ACCURACY OF ±2 °C

Same as PCT2075, with the following differences:

- Accuracy (max): ±2 °C (from -25 to 100 °C)
- Shutdown/operating current (max): 1.0/300 µA
- Bus: two-wire I²C-bus (400 kHz Fast Mode)

FEATURES ADVANTAGES

- Higher accuracy improves thermal guard-banding
- One-shot conversion helps improve performance in power-sensitive applications
- Programmable conversion helps enable more flexible system applications
- Programmable fault queue prevents false temperature trips

LOCAL-ONLY TEMPERATURE SENSORS, CONT.

LOCAL TEMPERATURE SENSOR SE98A FOR DDR3 RDIMM WITH ACCURACY OF ±1 °C

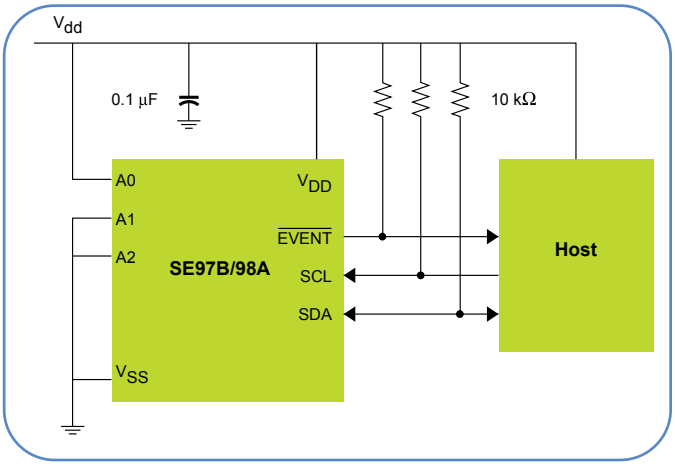
Features:

- Complies with JEDEC JC42.4
- Bus: two-wire SMBus or I²C-bus (standard/fast-mode compatible)
- Accuracy (max): ±1 °C (from 75 to 90 °C)
- Resolution: 11-bit (0.125 °C)
- Minimum conversion rate: 8 Hz
- Programmable hysteresis threshold: 0, 1.5, 3, or 6 °C
- EVENT output associated with three alarms: upper, lower, and critical
- Programmable SMBus alert response and timeout
- Security lock bit for data protection
- Maximum operating current: 100 µA
- I²C address: 0011A2A1A0 (up to 8 devices on same bus)
- Operating-voltage range: 1.7 to 3.6 V
- Operating temperature: -40 to +125 °C
- Packages: HWSON8 package

Benefits:

- SMBus timeout prevents system bus hang-ups
- SMBus alert response enables system polling
- Over-, under-, and critical-temperature status and alarm output
- Security lock bit for data protection

SE97B/98A APPLICATION DIAGRAM

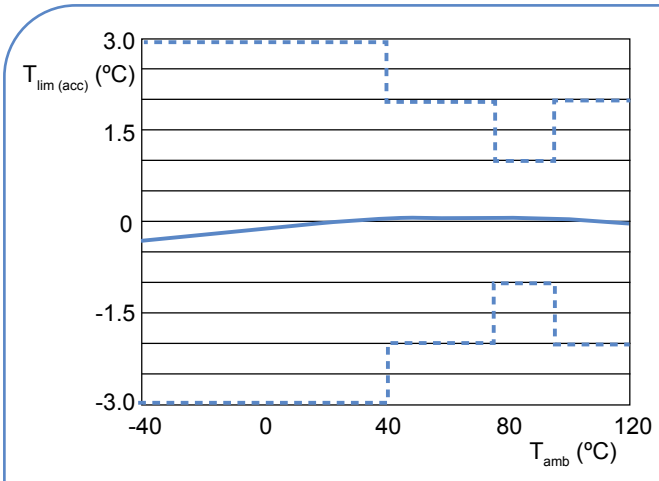


LOCAL TEMPERATURE SENSOR SE97B FOR DDR3 RDIMM WITH INTEGRATED SPD

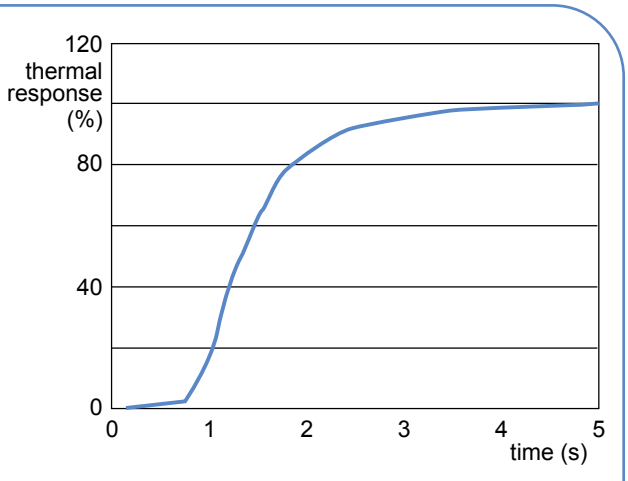
Same as SE98, with the following differences:

- Adds integrated 2-Kbit EEPROM for Serial Presence Detect
- EEPROM I²C-bus address 1010A2A1A0
- Operating-voltage range: 3.0 to 3.6V

SE98A AND SE97B THERMAL RESPONSE



Temperature Accuracy (Max)



From 25 °C to 120 °C (oil bath) at 3.3 V.

Package Thermal Response

REMOTE AND LOCAL TEMPERATURE SENSOR

REMOTE AND LOCAL TEMPERATURE SENSOR SA56004 WITH FAN CONTROL AND ACCURACY OF ±1 °C

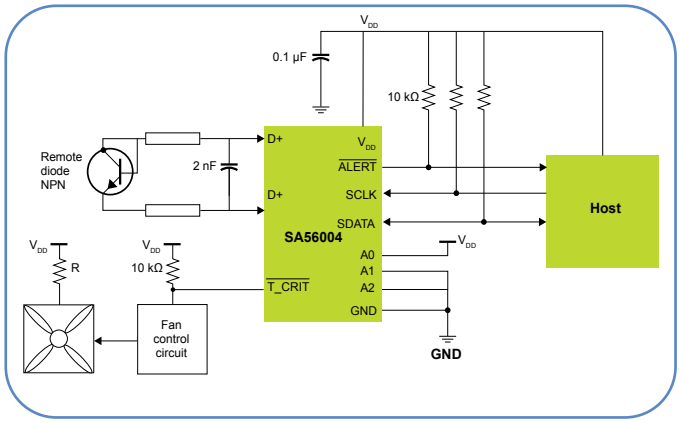
Features:

- Bus: two-wire SMBus or I²C-bus (standard/fast-mode compatible)
- Accuracy (remote sensing) (Max): ±1 °C (from 60 to 100 °C)
- Accuracy: (local sensing) (Max): ±2 °C (from 60 to 100 °C)
- Resolution: 11-bit (0.125 °C)
- Shutdown/operating current (typ): 10/500 µA
- Shutdown mode and one-shot conversion for power savings
- Offset registers for system calibration
- ALERT/T_CRIT output for interrupt/fan control (on/off)
- Supports SMBus alert response and timeout
- Fault queue prevents noise-triggered temperature trips
- Supports diode-fault detection
- Three device addresses for server applications (“E” most commonly used - also A and C)
- Temperature range: -55 to 125 °C
- Power-supply range: 3.0 to 3.6 V
- Packages: TSSOP(MSOP)8, SO8 and HVSON8
- Drop-in replacement for National LM86, Maxim MAX6657/8, Analog Devices ADM1032

Benefits:

- SMBus timeout prevents system bus hang-ups
- SMBus alert response enables system polling
- Fault queue prevents false temperature trips
- Programmable conversion rate for system flexibility

SA56004 APPLICATION DIAGRAM



SELECTION GUIDE AND CROSS REFERENCE

Selection guide

	Part Number	Package	Order Information	I²C/SMBus Speed (kHz)	Temperature Range (°C)	Power Supply Range (V)	Max Accuracy (±°C)		A/D Resolution (°C / # bits)	Max Supply Current (µA)		Channels		Thermal-Alarm Output (Open Drain)	Fan-Control Output (Open Drain)
							Local	Remote		Operating	Shutdown	Local	Remote		
Local	LM75B	XSON8U, HWSON8, HVSON8	LM75BGD, LM75BTP, SA56004XTK*	400	-25 to 100, -55 to 125	2.8 to 5.5	2 3	N/A	0.125/11	300	1.0	1	N/A	1	--
	PCT2075	SO8, MSOP8, HWSON8, TSOP6	PCT2075D, PCT2075DP, PCT2075TP, PCT2075GV	1000	-25 to 100 °C -55 to 125 °C	2.7 - 5.5	1 2	N/A	0.125/11	400	20 (@125 °C)	1	N/A	1	--
	SE97B	WSON8	SE97BTP	400	75 to 95 40 to 125 -40 to 125	3.0 to 3.6	1 2 3	N/A	0.125/11	400	10	1 with EEPROM	N/A	1	--
	SE98A	WSON8	SE98ATP	400	75 to 95 40 to 125 -40 to 125	1.7 to 3.6	1 2 3	N/A	0.125/11	400	5	1	N/A	1	--
Remote and Local	SA56004	SO8, MSOP8	SA56004XD*, SA56004XDP*	400	60 to 100 -40 to 125	3.0 to 3.6	2 3	1 3	0.125/11	500 (typ)	10 (typ)	1	1	1	1

* "X" is the version, with "A", "C" and "E" available and "E" the most commonly used.

CROSS-REFERENCE CHART

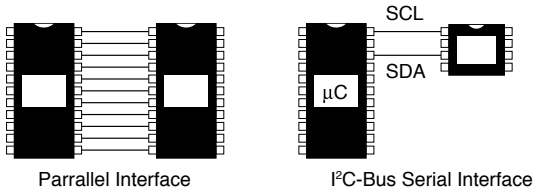
Package	NXP	National	Analog Devices	Maxim	Texas Instruments	Microchip
SO8	LM75BD	LM75BIM LM75CIM	AD7416AR	DS75S	TMP75AID	TCN75-3.3MOA TCN75-5.0MOA
TSSOP8	LM75BDP	LM75BIMM LM75CIMM	AD7416ARM			TCN75-3.3MUA TCN75-5.0MUA
SO8	SA56004ED	LM86CIM	ADM1032AR	MAX6657MSA MAX6658MSA		
TSSOP8	SA56004EDP	LM86CIMM	ADM1032ARM			

I²C-BUS AND SMBUS: AN OVERVIEW

The Inter-IC bus, commonly known as the I²C-bus ("eye-squared-see bus"), is a simple, two-wire serial interface that provides the communications link between integrated circuits in a system. Developed by Philips in the early 1980s, the I²C-bus has become the de facto worldwide standard for system control and today can be found in everything from temperature sensors to EEPROMs, general-purpose I/O, A/D and D/A converters, CODECs, and microprocessors of all kinds.

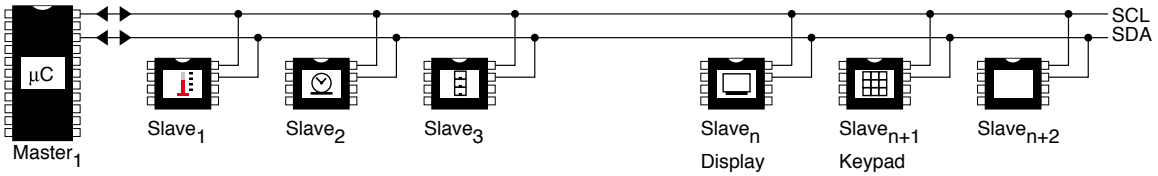
LOW-COST SERIAL INTERFACE

The two-wire, serial structure of the I²C-bus lets it deliver the same functionality as a larger, more expensive parallel interface, but with far fewer pins. The data wire (SDA) carries data, while the clock wire (SCL) synchronizes data transfers.



MASTER-SLAVE HIERARCHY

I²C-bus devices are classified as master or slave. Masters initiate a message and slaves respond to a message. A master can have multiple slaves and any device can be master-only, slave-only, or switch between master and slave, as the application requires.



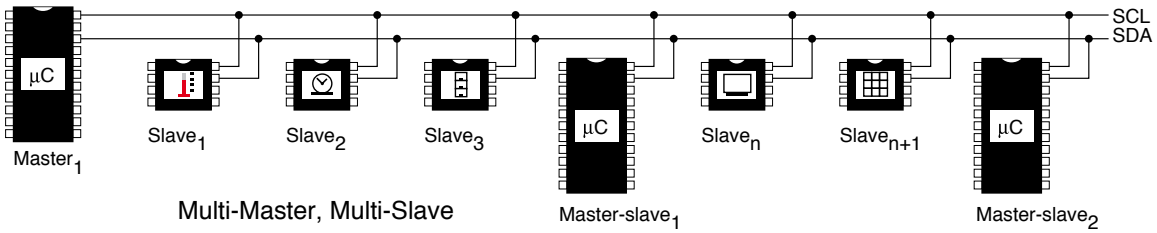
One I²C-Bus Master, Multiple Slaves

MULTIPLE DEVICES

The I²C-bus is designed to support multiple devices. Each I²C-bus slave device has a unique slave address. When a master sends a message, it includes the slave address at the beginning of the message. All devices on the bus hear the message, but only the addressed slave responds to it.

MULTI-MASTER SUPPORT

There can be more than one master on the bus at a time—the I²C-bus software uses arbitration and synchronization to prevent collisions and data loss. A master that detects arbitration loss terminates its use of the bus, allowing the message generated by another master to use the bus without interference.



Multi-Master, Multi-Slave

I²C-BUS AND SMBUS: AN OVERVIEW

I²C-BUS VS. SMBUS

The system management bus, also known as the SMBus, was developed by Intel in the mid-1990s. It is a popular derivative of the I²C-bus that is, in most cases, compatible with I²C-bus formats. Both buses use a two-wire, master/slave communication scheme and have addressable slaves. The SMBus is limited to a maximum data transfer rate of only 100 kbit/s, so it requires special handling in systems that use the higher transfer rates available with the I²C-bus. Other differences include the maximum timeout period, minimum clock speed, voltage levels, pull-up resistors values and current levels.

MIXING I2C-BUS AND SMBUS MASTER AND SLAVE DEVICES

Although there are minor differences between the various I²C-bus and SMBus standards, it's possible to mix master and slave devices from different versions. Two factors need to be considered. First, the SMBus timeout maximum of 35 ms can restrict the performance of an I²C-bus master, but the timeout feature in most SMBus slaves can be programmed on or off. Second, the SMBus data hold time of 300 ns can also restrict I²C-bus performance, but many SMBus devices (including those from NXP) can stretch the internal data-hold time.

Feature	I²C-Bus	SMBus	
Slave interface reset	Master sends clock pulses until slave data goes high (typically nine clocks) or hardware reset	Master holds clock low for maximum 35 ms (time-out period)	
Clock speed (min/max)	0 to 3.4 MHz	10 to 100 kHz	
SMBus alert	No	Optional	
VILmax	0.3 V_{DD} (or fixed 1.5 V)	0.8 V	
VIHmin	0.7 V_{DD} (or fixed 3.0 V)	2.1 V	
		Low power (Version 1.1)	High power (Version 2.0)
IPULLUP	3 mA	350 µA	4 mA
Pull-up resistor1 for V_{DD} = 3.3 V (±10%)	> 0.8 kW	> 7.4 kW	> 0.65 kW
Pull-up resistor1 for V_{DD} = 5.0 V (±10%)	> 1.6 kW	> 13.2 kW	> 1.2 kW
Data hold time	Performed internally	300 ns (externally)	

1 Pull-up resistor value calculation based on V_{DD} = V_{DD}–min

I²C-Bus Slave	SMBus Slave
I²C-bus master OK	OK, but ensure clock speed is greater than 10 kHz and check for data potential hold-time violations when the slave is receiving.*
SMBus master OK	OK

* All NXP temperature sensors with an SMBus interface have internal holdtime without hold-time violations.

For current information about NXP products and documentation, please visit www.nxp.com/i2c.

Document number: 9397 750 15693A4 REV 1