

LM75

Digital Temperature Sensor and Thermal Watchdog with Two-Wire Interface

General Description


The LM75 is a temperature sensor, Delta-Sigma analog-to-digital converter, and digital over-temperature detector with I²C® interface. The host can query the LM75 at any time to read temperature. The open-drain Overtemperature Shutdown (O.S.) output becomes active when the temperature exceeds a programmable limit. This pin can operate in either "Comparator" or "Interrupt" mode.

The host can program both the temperature alarm threshold (T_{OS}) and the temperature at which the alarm condition goes away (T_{HYST}). In addition, the host can read back the contents of the LM75's T_{OS} and T_{HYST} registers. Three pins (A0, A1, A2) are available for address selection. The sensor powers up in Comparator mode with default thresholds of 80°C T_{OS} and 75°C T_{HYST}.

The LM75's 3.0V to 5.5V supply voltage range, low supply current and I²C interface make it ideal for a wide range of applications. These include thermal management and protection applications in personal computers, electronic test equipment, and office electronics.

Features

- SOP-8 and Mini SOP-8 (MSOP) packages save space
- I²C Bus interface
- Separate open-drain output pin operates as interrupt or comparator/thermostat output

- Register readback capability
- Power up defaults permit stand-alone operation as thermostat
- Shutdown mode to minimize power consumption
- Up to 8 LM75s can be connected to a single bus
- UL Recognized Component 

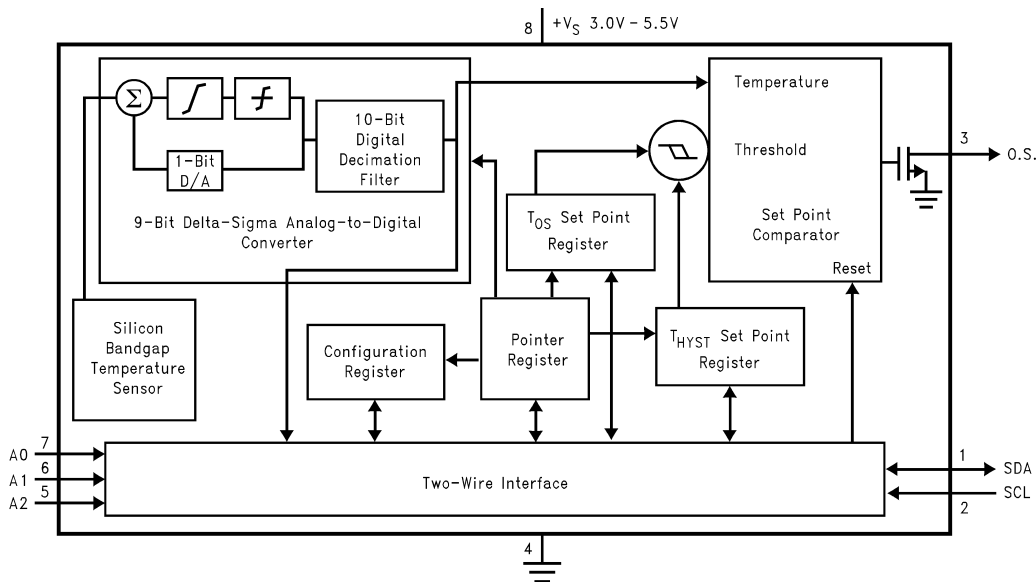
Key Specifications

■ Supply Voltage		3.0V to 5.5V
■ Supply Current	operating	250 µA (typ) 1 mA (max)
	shutdown	4 µA (typ)
■ Temperature Accuracy	-25°C to 100°C	±2°C(max)
	-55°C to 125°C	±3°C(max)

Applications

- System Thermal Management
- Personal Computers
- Office Electronics
- Electronic Test Equipment

Simplified Block Diagram

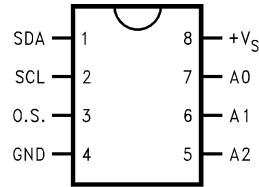


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Connection Diagram

SOP-8 and Mini SOP-8



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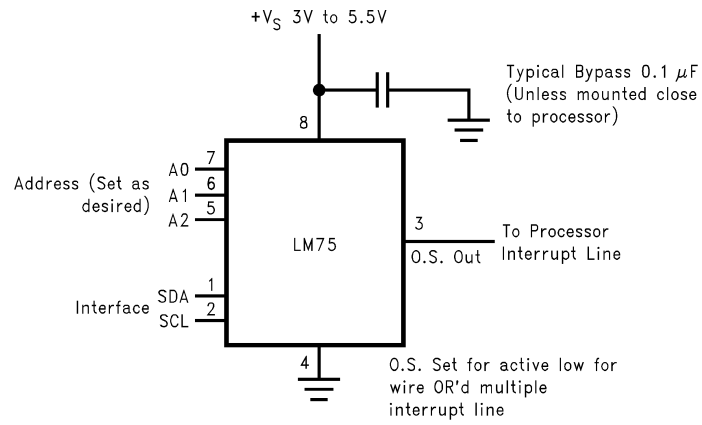
Ordering Information

Order Number	Package Marking	NS Package Number	Supply Voltage	Transport Media	Noise Filter on SDA and SCL
LM75BIM-3	LM75BIM-3	M08A (SOP-8)	3.3V	95 Units in Rail	Yes
LM75BIMX-3	LM75BIM-3	M08A (SOP-8)	3.3V	2500 Units on Tape and Reel	Yes
LM75BIMM-3	T01B	MUA08A (MSOP-8)	3.3V	1000 Units on Tape and Reel	Yes
LM75BIMMX-3	T01B	MUA08A (MSOP-8)	3.3V	3500 Units on Tape and Reel	Yes
LM75BIM-5	LM75BIM-5	M08A (SOP-8)	5V	95 Units in Rail	Yes
LM75BIMX-5	LM75BIM-5	M08A (SOP-8)	5V	2500 Units on Tape and Reel	Yes
LM75BIMM-5	T00B	MUA08A (MSOP-8)	5V	1000 Units on Tape and Reel	Yes
LM75BIMMX-5	T00B	MUA08A (MSOP-8)	5V	3500 Units on Tape and Reel	Yes
LM75CIM-3	LM75CIM-3	M08A (SOP-8)	3.3V	95 Units in Rail	Not Available
LM75CIMX-3	LM75CIM-3	M08A (SOP-8)	3.3V	2500 Units on Tape and Reel	Not Available
LM75CIMM-3	T01C	MUA08A (MSOP-8)	3.3V	1000 Units on Tape and Reel	Not Available
LM75CIMMX-3	T01C	MUA08A (MSOP-8)	3.3V	3500 Units on Tape and Reel	Not Available
LM75CIM-5	LM75CIM-5	M08A (SOP-8)	5V	95 Units in Rail	Not Available
LM75CIMX-5	LM75CIM-5	M08A (SOP-8)	5V	2500 Units on Tape and Reel	Not Available
LM75CIMM-5	T00C	MUA08A (MSOP-8)	5V	1000 Units on Tape and Reel	Not Available
LM75CIMMX-5	T00C	MUA08A (MSOP-8)	5V	3500 Units on Tape and Reel	Not Available

Pin Descriptions

Label	Pin #	Function	Typical Connection
SDA	1	I ² C Serial Bi-Directional Data Line. Open Drain.	From Controller, tied to a pull-up
SCL	2	I ² C Clock Input	From Controller
O.S.	3	Overtemperature Shutdown Open Drain Output	Pull-up Resistor, Controller Interrupt Line
GND	4	Power Supply Ground	Ground
+V _S	8	Positive Supply Voltage Input	DC Voltage from 3V to 5.5V; 0.1μF bypass capacitor with 10μF bulk capacitance in the near vicinity
A0–A2	7,6,5	User-Set I ² C Address Inputs	Ground (Low, “0”) or +V _S (High, “1”)

Typical Application



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FIGURE 1. Typical Application

Absolute Maximum Ratings (Note 1)

Supply Voltage	-0.3V to 6.5V
Voltage at any Pin	-0.3V to $+V_S + 0.3V$
Input Current at any Pin (Note 2)	5 mA
Package Input Current (Note 2)	20 mA
O.S. Output Sink Current	10 mA
O.S. Output Voltage	6.5V
Storage Temperature	-65°C to +150°C
Soldering Information, Lead Temperature	
SOP and MSOP Package (Note 3)	
Vapor Phase (60 seconds)	215°C
Infrared (15 seconds)	220°C

ESD Susceptibility (Note 4)

Human Body Model	LM75B	LM75C
	2500V	1500V
Machine Model	250V	100V

Operating Ratings

Specified Temperature Range (Note 5)	T_{MIN} to T_{MAX} -55°C to +125°C
Supply Voltage Range ($+V_S$)	+3.0V to +5.5V

Temperature-to-Digital Converter Characteristics

Unless otherwise noted, these specifications apply for $+V_S = +5$ Vdc for LM75BIM-5, LM75BIMM-5, LM75CIM-5, and LM75CIMM-5 and $+V_S = +3.3$ Vdc for LM75BIM-3, LM75BIMM-3, LM75CIM-3, and LM75CIMM-3 (Note 6). **Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX}** ; all other limits $T_A = T_J = +25^\circ\text{C}$, unless otherwise noted.

Parameter	Conditions	Typical (Note 12)	Limits (Note 7)	Units (Limit)	
Accuracy	$T_A = -25^\circ\text{C}$ to $+100^\circ\text{C}$		± 2.0	$^\circ\text{C}$ (max)	
	$T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$		± 3.0	$^\circ\text{C}$ (max)	
Resolution		9		Bits	
Temperature Conversion Time	(Note 8)	100	300	ms (max)	
Quiescent Current	LM75B	I ² C Inactive	0.25	0.5	mA (max)
		Shutdown Mode, $+V_S = 3V$	4		μA
		Shutdown Mode, $+V_S = 5V$	6		μA
	LM75C	I ² C Inactive	0.25	1.0	mA (max)
		Shutdown Mode, $+V_S = 3V$	4		μA
		Shutdown Mode, $+V_S = 5V$	6		μA
O.S. Output Saturation Voltage	I _{OUT} = 4.0 mA (Note 9)		0.8	V (max)	
O.S. Delay	(Note 10)		1	Conversions (min)	
			6	Conversions (max)	
T _{OS} Default Temperature	(Note 11)	80		$^\circ\text{C}$	
T _{HYST} Default Temperature	(Note 11)	75		$^\circ\text{C}$	

Logic Electrical Characteristics

DIGITAL DC CHARACTERISTICS Unless otherwise noted, these specifications apply for $+V_S = +5$ Vdc for LM75BIM-5, LM75BIMM-5, LM75CIM-5, and LM75CIMM-5 and $+V_S = +3.3$ Vdc for LM75BIM-3, LM75BIMM-3, LM75CIM-3, and LM75CIMM-3 (Note 6). **Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX}** ; all other limits $T_A = T_J = +25^\circ\text{C}$, unless otherwise noted.

Symbol	Parameter	Conditions	Typical (Note 12)	Limits (Note 7)	Units (Limit)
V _{IN(1)}	Logical "1" Input Voltage			$+V_S \times 0.7$	V (min)
				$+V_S + 0.5$	V (max)
V _{IN(0)}	Logical "0" Input Voltage			-0.3	V (min)
				$+V_S \times 0.3$	V (max)
I _{IN(1)}	Logical "1" Input Current	V _{IN} = 5V	0.005	1.0	μA (max)
I _{IN(0)}	Logical "0" Input Current	V _{IN} = 0V	-0.005	-1.0	μA (max)
C _{IN}	All Digital Inputs		20		pF
I _{OH}	High Level Output Current	LM75B	V _{OH} = 5V	10	μA (max)
		LM75C	V _{OH} = 5V	100	μA (max)
V _{OL}	Low Level Output Voltage	I _{OL} = 3 mA		0.4	V (max)

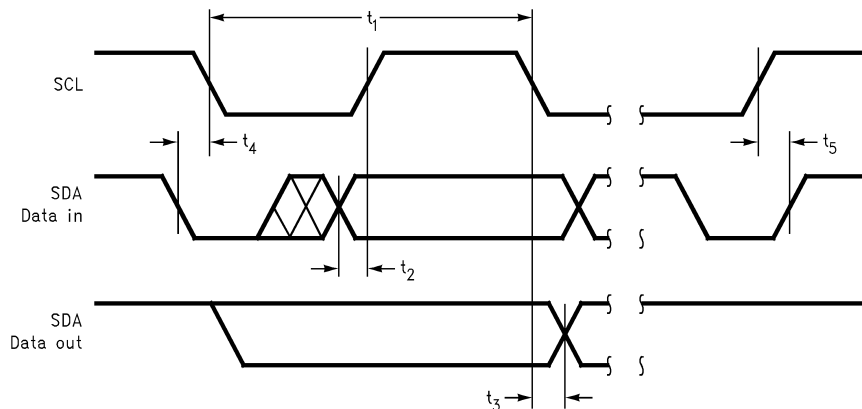
Logic Electrical Characteristics (Continued)

DIGITAL DC CHARACTERISTICS Unless otherwise noted, these specifications apply for $+V_S = +5$ Vdc for LM75BIM-5, LM75BIMM-5, LM75CIM-5, and LM75CIMM-5 and $+V_S = +3.3$ Vdc for LM75BIM-3, LM75BIMM-3, LM75CIM-3, and LM75CIMM-3 (Note 6). **Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX}** ; all other limits $T_A = T_J = +25^\circ\text{C}$, unless otherwise noted.

Symbol	Parameter	Conditions	Typical (Note 12)	Limits (Note 7)	Units (Limit)
t_{OF}	Output Fall Time	$C_L = 400$ pF $I_O = 3$ mA		250	ns (max)

I²C DIGITAL SWITCHING CHARACTERISTICS Unless otherwise noted, these specifications apply for $+V_S = +5$ Vdc for LM75BIM-5, LM75BIMM-5, LM75CIM-5, and LM75CIMM-5 and $+V_S = +3.3$ Vdc for LM75BIM-3, LM75BIMM-3, LM75CIM-3, and LM75CIMM-3. C_L (load capacitance) on output lines = 80 pF unless otherwise specified. **Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX}** ; all other limits $T_A = T_J = +25^\circ\text{C}$, unless otherwise noted. The switching characteristics of the LM75 fully meet or exceed the published specifications of the I²C bus. The following parameters are the timing relationships between SCL and SDA signals related to the LM75. They are not the I²C bus specifications.

Symbol	Parameter	Conditions	Typical (Note 12)	Limits (Note 7)	Units (Limit)
t_1	SCL (Clock) Period			2.5	μs (min)
t_2	Data in Set-Up Time to SCL High			100	ns (min)
t_3	Data Out Stable after SCL Low			0	ns (min)
t_4	SDA Low Set-Up Time to SCL Low (Start Condition)			100	ns (min)
t_5	SDA High Hold Time after SCL High (Stop Condition)			100	ns (min)
$t_{TIMEOUT}$	SDA Time Low for Reset of Serial Interface (Note 13)	LM75B		75 325	ms (min) ms (max)
		LM75C		Not Applicable	



Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its rated operating conditions.

Note 2: When the input voltage (V_I) at any pin exceeds the power supplies ($V_I < \text{GND}$ or $V_I > +V_S$) the current at that pin should be limited to 5 mA. The 20 mA maximum package input current rating limits the number of pins that can safely exceed the power supplies with an input current of 5 mA to four.

Note 3: See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" or the section titled "Surface Mount" found in a current National Semiconductor Linear Data Book for other methods of soldering surface mount devices.

Note 4: Human body model, 100 pF discharged through a 1.5 k Ω resistor. Machine model, 200 pF discharged directly into each pin.

Note 5: LM75 θ_{JA} (thermal resistance, junction-to-ambient) when attached to a printed circuit board with 2 oz. foil similar to the one shown in Figure 3 is summarized in the table below:

Device Number	NS Package Number	Thermal Resistance (θ_{JA})
LM75BIM-3, LM75BIM-5, LM75CIM-3, LM75CIM-5	M08A	200°C/W
LM75BIMM-3, LM75BIMM-5, LM75CIMM-3, LM75CIMM-5	MUA08A	250°C/W

Note 6: All part numbers of the LM75 will operate properly over the $+V_S$ supply voltage range of 3V to 5.5V. The devices are tested and specified for rated accuracy at their nominal supply voltage. Accuracy will typically degrade 1°C/V of variation in $+V_S$ as it varies from the nominal value.

Note 7: Limits are guaranteed to National's AOQL (Average Outgoing Quality Level).