19-3476; Rev 3; 8/07

EVALUATION KIT AVAILABLE

MAXIM

7-Channel Precision Remote-Diode, Thermistor, and Local Temperature Monitor

MAX6698

General Description

The MAX6698 precision multichannel temperature sensor monitors its own temperature, the temperatures of three external diode-connected transistors, and the temperatures of three thermistors. All temperature channels have programmable alert thresholds. Channels 1, 4, 5, and 6 also have programmable overtemperature thresholds. When the measured temperature of a channel exceeds the respective threshold, a status bit is set in one of the status registers. Two open-drain outputs, $\overline{\text{OVERT}}$ and $\overline{\text{ALERT}}$, assert corresponding to these bits in the status register.

The 2-wire serial interface supports the standard system management bus (SMBus™) protocols: write byte, read byte, send byte, and receive byte for reading the temperature data and programming the alarm thresholds.

The MAX6698 is specified for an operating temperature range of -40°C to +125°C and is available in 16-pin QSOP and 16-pin TSSOP packages.

Applications

Desktop Computers
Notebook Computers
Workstations
Servers

Features

- ♦ Three Thermal-Diode Inputs and Three Thermistor Inputs
- ♦ Local Temperature Sensor
- ♦ 1°C Remote Temperature Accuracy (+60°C to +100°C)
- ♦ Temperature Monitoring Begins at POR for Fail-Safe System Protection
- ♦ $\overline{\text{ALERT}}$ and $\overline{\text{OVERT}}$ Outputs for Interrupts, Throttling, and Shutdown
- ♦ Small 16-Pin QSOP and 16-Pin TSSOP Packages
- ♦ 2-Wire SMBus Interface

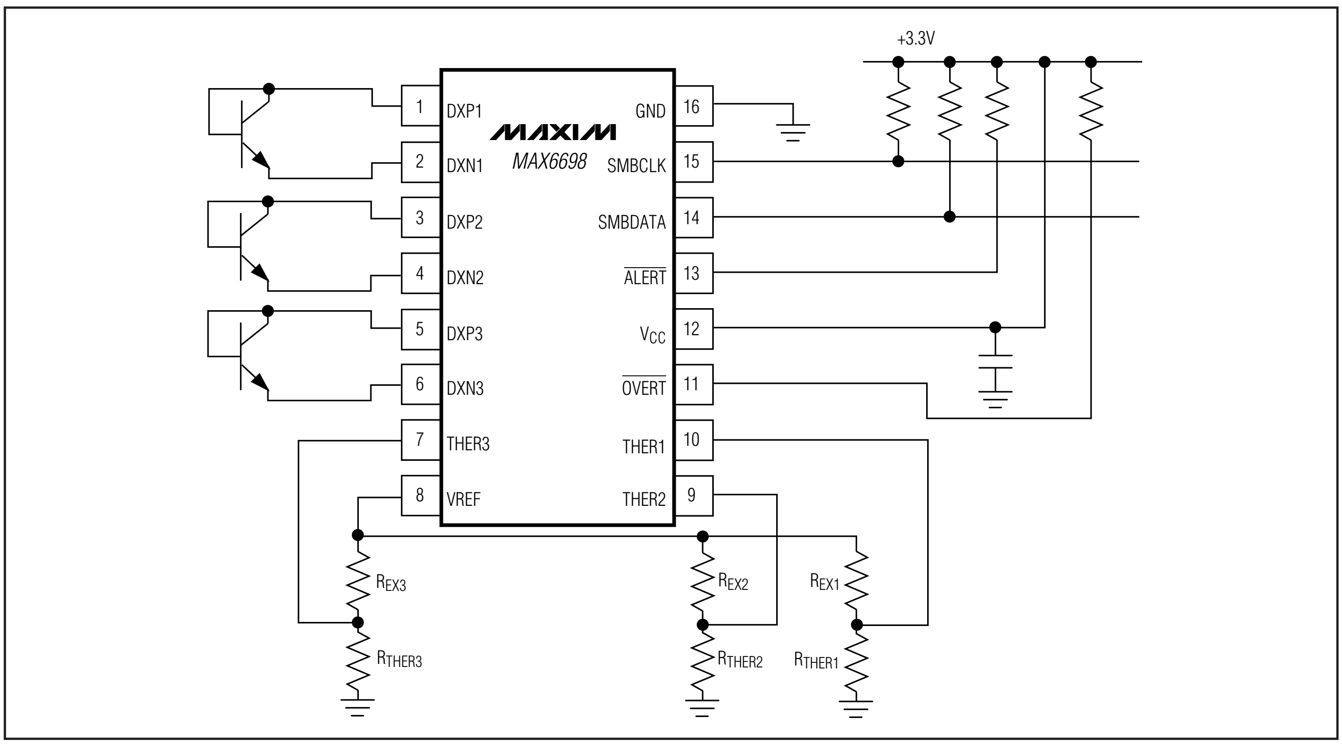
Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	PKG CODE
MAX6698EE_ _	-40°C to +125°C	16 QSOP	E16-1
MAX6698UE_ _	-40°C to +125°C	16 TSSOP	U16-1

*See the Slave Address section.

Pin Configuration appears at end of data sheet.

Typical Application Circuit



7-Channel Precision Remote-Diode, Thermistor, and Local Temperature Monitor

ABSOLUTE MAXIMUM RATINGS

V_{CC}, SCL, SDA, $\overline{\text{ALERT}}$, $\overline{\text{OVERT}}$ to GND ....-0.3V to +6V
DXP_ to GND...-0.3V to (V_{CC} + 0.3V)
DXN_ to GND ....-0.3V to +0.8V
THER_ to GND...-0.3V to +6V
VREF to GND...-0.3V to +6V
SDA, $\overline{\text{ALERT}}$, $\overline{\text{OVERT}}$ Current ....-1mA to +50mA
DXN Current ....±1mA
Continuous Power Dissipation (T_A = +70°C)
16-Pin QSOP
(derate 8.3mW/°C above +70°C) ....666.7mW(E16-1)
16-Pin TSSOP
(derate 9.4mW/°C above +70°C)....................754.7mW(U16-1)
ESD Protection (all pins, Human Body Model)................±2000V
Operating Temperature Range ....-40°C to +125°C
Junction Temperature...+150°C
Storage Temperature Range ....-60°C to +150°C
Lead Temperature (soldering, 10s) ....+300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V_{CC} = +3.0V to +5.5V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at V_{CC} = +3.3V and T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage	V_{CC}		3.0		5.5	V
Standby Supply Current	I_{SS}	SMBus static		30		µA
Operating Current	I_{CC}	During conversion		500	1000	µA
Temperature Resolution		Channel 1 only		11		Bits
		Other diode channels		8		
Remote Temperature Accuracy		V_{CC} = 3.3V, $T_A = T_{RJ}$ = +60°C to +100°C	-1.0		+1.0	°C
		V_{CC} = 3.3V, $T_A = T_{RJ}$ = 0°C to +125°C	-3.0		+3.0	
		V_{CC} = 3.3V, DXN_ grounded, $T_{RJ} = T_A$ = 0°C to +85°C			±2.5	
Local Temperature Accuracy		V_{CC} = 3.3V, T_A = +60°C to +100°C	-2.5		+2.5	°C
		V_{CC} = 3.3V, T_A = 0°C to +125°C	-3.5		+3.5	
Supply Sensitivity of Temperature Accuracy				±0.2		°C/V
Remote Channel 1 Conversion Time	t_{CONV1}	Resistance cancellation on	95	125	156	ms
		Resistance cancellation off	190	250	312	
Remote Channels 2 Through 6 Conversion Time	$t_{CONV\_}$		95	125	156	ms
Remote-Diode Source Current	I_{RJ}	High level	80	100	120	µA
		Low level	8	10	12	
Undervoltage-Lockout Threshold	UVLO	Falling edge of V_{CC} disables ADC	2.3	2.80	2.95	V
Undervoltage-Lockout Hysteresis				90		mV
Power-On Reset (POR) Threshold		V_{CC} falling edge	1.2	2.0	2.5	V
POR Threshold Hysteresis				90		mV
THERMISTOR CONVERSION						
Voltage-Measurement Accuracy			-1		+1	%Full scale
Conversion Time				31		ms
Thermistor Reference Voltage	V_{REF}			1		V

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = +3.0V to +5.5V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at V_{CC} = +3.3V and T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Reference-Load Regulation		0mA < I_{REF} < 2mA			0.4	%
Reference-Supply Rejection					0.5	%/V
$\overline{ALERT}$, $\overline{OVERT}$						
Output Low Voltage	V_{OL}	I_{SINK} = 1mA			0.3	V
		I_{SINK} = 6mA			0.5	
Output Leakage Current					1	µA
SMBus INTERFACE (SCL, SDA)						
Logic-Input Low Voltage	V_{IL}				0.8	V
Logic-Input High Voltage	V_{IH}	V_{CC} = 3.0V	2.2			V
		V_{CC} = 5.0V	2.4			V
Input Leakage Current			-1		+1	µA
Output Low Voltage	V_{OL}	I_{SINK} = 6mA			0.3	V
Input Capacitance	C_{IN}			5		pF
SMBus-COMPATIBLE TIMING (Figures 3 and 4) (Note 2)						
Serial Clock Frequency	f_{SCL}	(Note 3)			400	kHz
Bus Free Time Between STOP and START Condition	t_{BUF}	f_{SCL} = 100kHz	4.7			µs
		f_{SCL} = 400kHz	1.6			
START Condition Setup Time		f_{SCL} = 100kHz	4.7			µs
		f_{SCL} = 400kHz	0.6			
Repeat START Condition Setup Time	$t_{SU:STA}$	90% of SCL to 90% of SDA, f_{SCL} = 100kHz	0.6			µs
		90% of SCL to 90% of SDA, f_{SCL} = 400kHz	0.6			
START Condition Hold Time	$t_{HD:STA}$	10% of SDA to 90% of SCL	0.6			µs
STOP Condition Setup Time	$t_{SU:STO}$	90% of SCL to 90% of SDA, f_{SCL} = 100kHz	4			µs
		90% of SCL to 90% of SDA, f_{SCL} = 400kHz	0.6			
Clock Low Period	t_{LOW}	10% to 10%, f_{SCL} = 100kHz	1.3			µs
		10% to 10%, f_{SCL} = 400kHz	1.3			
Clock High Period	t_{HIGH}	90% to 90%	0.6			µs
Data Hold Time	$t_{HD:DAT}$	f_{SCL} = 100kHz	300			ns
		f_{SCL} = 400kHz (Note 4)			900	
Data Setup Time	$t_{SU:DAT}$	f_{SCL} = 100kHz	250			ns
		f_{SCL} = 400kHz	100			
Receive SCL/SDA Rise Time	t_R	f_{SCL} = 100kHz			1	µs
		f_{SCL} = 400kHz			0.3	
Receive SCL/SDA Fall Time	t_F				300	ns
Pulse Width of Spike Suppressed	t_{SP}		0		50	ns
SMBus Timeout	$t_{TIMEOUT}$	SDA low period for interface reset	25	37	45	ms

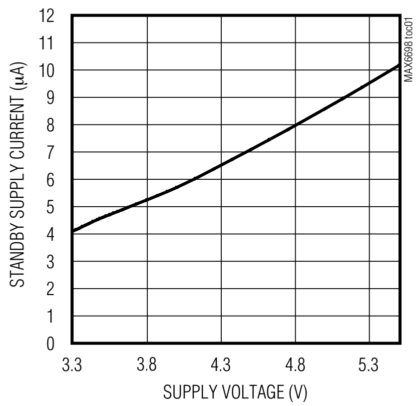
Note 1: All parameters are tested at T_A = +25°C. Specifications over temperature are guaranteed by design.
Note 2: Timing specifications are guaranteed by design.
Note 3: The serial interface resets when SCL is low for more than $t_{TIMEOUT}$.
Note 4: A transition must internally provide at least a hold time to bridge the undefined region (300ns max) of SCL's falling edge.

7-Channel Precision Remote-Diode, Thermistor, and Local Temperature Monitor

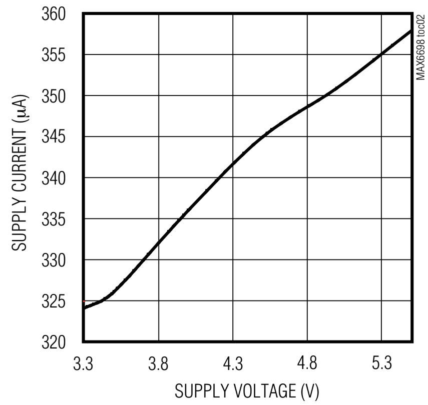
Typical Operating Characteristics

(V_{CC} = 3.3V, T_A = +25°C, unless otherwise noted.)

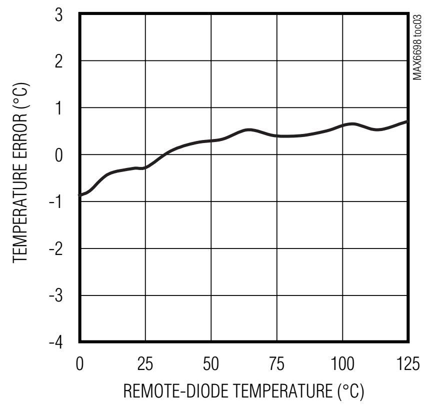
STANDBY SUPPLY CURRENT vs. SUPPLY VOLTAGE



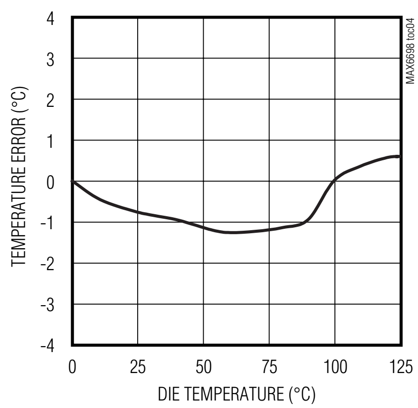
SUPPLY CURRENT vs. SUPPLY VOLTAGE



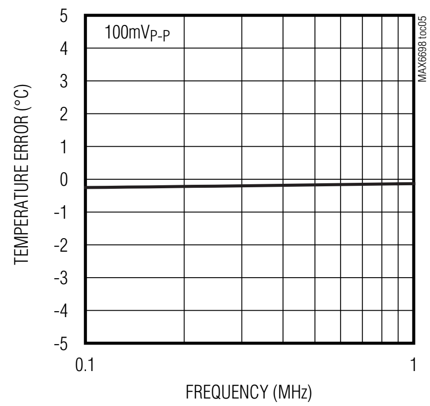
REMOTE TEMPERATURE ERROR vs. REMOTE-DIODE TEMPERATURE



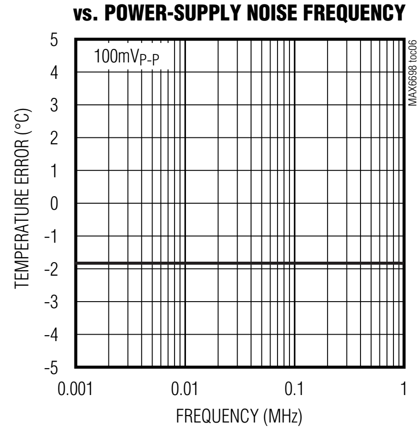
LOCAL TEMPERATURE ERROR vs. DIE TEMPERATURE



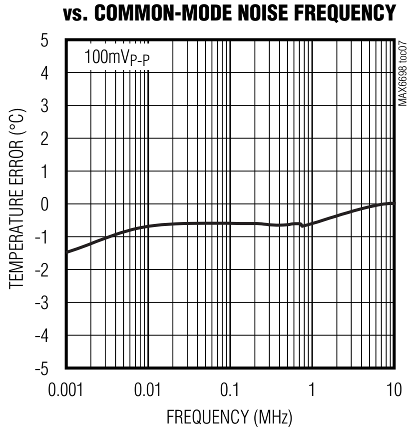
REMOTE-DIODE TEMPERATURE ERROR vs. POWER-SUPPLY NOISE FREQUENCY



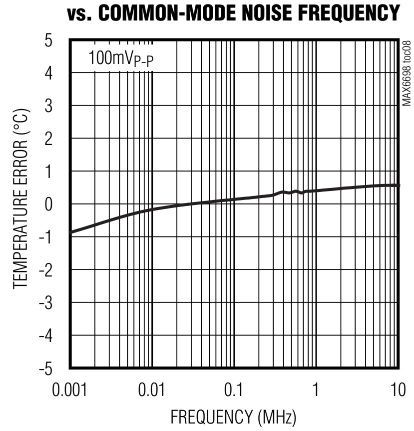
LOCAL TEMPERATURE ERROR vs. POWER-SUPPLY NOISE FREQUENCY



REMOTE TEMPERATURE ERROR vs. COMMON-MODE NOISE FREQUENCY

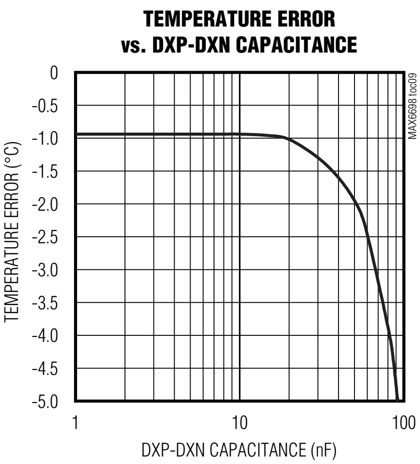


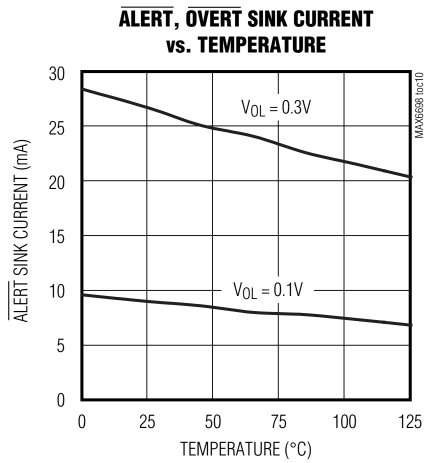
REMOTE TEMPERATURE ERROR vs. COMMON-MODE NOISE FREQUENCY

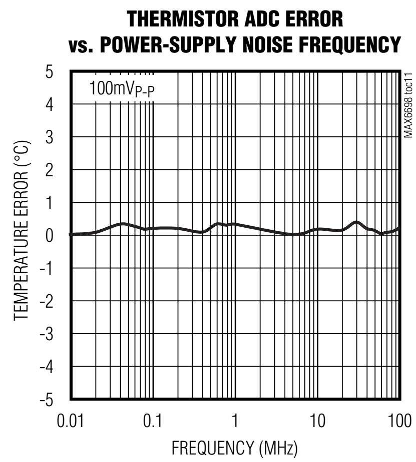


Typical Operating Characteristics (continued)

(V_{CC} = 3.3V, T_A = +25°C, unless otherwise noted.)







Pin Description

PIN	NAME	FUNCTION
1	DXP1	Combined Current Source and A/D Positive Input for Channel 1 Remote Diode. Connect to the anode of a remote-diode-connected temperature-sensing transistor. Leave floating or connect to V_{CC} if no remote diode is used. Place a 2200pF capacitor between DXP1 and DXN1 for noise filtering.
2	DXN1	Cathode Input for Channel 1 Remote Diode. Connect the cathode of the channel 1 remote-diode-connected transistor to DXN1.
3	DXP2	Combined Current Source and A/D Positive Input for Channel 2 Remote Diode. Connect to the anode of a remote-diode-connected temperature-sensing transistor. Leave floating or connect to V_{CC} if no remote diode is used. Place a 2200pF capacitor between DXP2 and DXN2 for noise filtering.
4	DXN2	Cathode Input for Channel 2 Remote Diode. Connect the cathode of the channel 2 remote-diode-connected transistor to DXN2.
5	DXP3	Combined Current Source and A/D Positive Input for Channel 3 Remote Diode. Connect to the anode of a remote-diode-connected temperature-sensing transistor. Leave floating or connect to V_{CC} if no remote diode is used. Place a 2200pF capacitor between DXP3 and DXN3 for noise filtering.
6	DXN3	Cathode Input for Channel 3 Remote Diode. Connect the cathode of the channel 1 remote-diode-connected transistor to DXN3.
7	THER3	Thermistor Voltage Sense Input 3. Connect thermistor 3 between THER3 and ground and an external resistor R_{EXT3} between THER3 and VREF.
8	VREF	Thermistor Reference Voltage (1V Nominal). VREF is automatically enabled for a thermistor conversion, and is disabled for diode measurements.

Pin Description (continued)

PIN	NAME	FUNCTION
9	THER2	Thermistor Voltage Sense Input 2. Connect thermistor 2 between THER2 and ground and an external resistor R_{EXT3} between THER2 and VREF.
10	THER1	Thermistor Voltage Sense Input 1. Connect thermistor 1 between THER1 and ground and an external resistor R_{EXT3} between THER1 and VREF.
11	$\overline{OVERT}$	Overtemperature Active-Low, Open-Drain Output. $\overline{OVERT}$ asserts low when the temperature of channels 1, 4, 5, and 6 exceed the programmed threshold limit.
12	V_{CC}	Supply Voltage Input. Bypass to GND with a 0.1µF capacitor.
13	$\overline{ALERT}$	SMBus Alert (Interrupt), Active-Low, Open-Drain Output. $\overline{ALERT}$ asserts low when the temperature of channels 1, 4, 5, and 6 exceed programmed threshold limit.
14	SMBDATA	SMBus Serial-Data Input/Output. Connect to a pullup resistor.
15	SMBCLK	SMBus Serial-Clock Input. Connect to a pullup resistor.
16	GND	Ground

Detailed Description

The MAX6698 is a precision multichannel temperature monitor that features one local, three remote thermal diode temperature-sensing channels, and three thermistor voltage-sensing channels. All channels have a programmable alert threshold for each temperature channel and a programmable overtemperature threshold for channels 1, 4, 5, and 6 (see Figure 1). Communication with the MAX6698 is achieved through the SMBus serial interface and a dedicated alert ($\overline{ALERT}$) pin. The alarm outputs, $\overline{OVERT}$ and $\overline{ALERT}$, assert if the software-programmed temperature thresholds are exceeded. $\overline{ALERT}$ typically serves as an interrupt, while $\overline{OVERT}$ can be connected to a fan, system shutdown, or other thermal-management circuitry.

Note that thermistor "temperature data" is really the voltage across the fixed resistor, R_{EXT}, in series with the thermistor. This voltage is directly related to temperature, but the data is expressed in percentage of the reference voltage not in °C.

ADC Conversion Sequence

In the default conversion mode, the MAX6698 starts the conversion sequence by measuring the temperature on the channel 1 remote diode, followed by the channel 2, remote diode, channel 3 remote diode, and the local channel. Then it measures thermistor channel 1, thermistor channel 2, and thermistor channel 3. The conversion result for each active channel is stored in the corresponding temperature data register.

In some systems, one of the remote thermal diodes may be monitoring a location that experiences temperature changes that occur much more rapidly than in the other channels. If faster temperature changes must be monitored in one of the temperature channels, the MAX6698 allows channel 1 to be monitored at a faster rate than the other channels. In this mode (set by writing a 1 to bit 4 of the configuration 1 register), measurements of channel 1 alternate with measurements of the other channels. The sequence becomes remote-diode channel 1, remote-diode channel 2, remote-diode channel 1, remote-diode channel 3, remote-diode channel 1, etc. Note that the time required to measure all seven channels is considerably greater in this mode than in the default mode.

Low-Power Standby Mode

Standby mode reduces the supply current to less than 15µA by disabling the internal ADC. Enter standby by setting the STOP bit to 1 in the configuration 1 register. During standby, data is retained in memory, and the SMBus interface is active and listening for SMBus commands. The timeout is enabled if a start condition is recognized on the SMBus. Activity on the SMBus causes the supply current to increase. If a standby command is received while a conversion is in progress, the conversion cycle is interrupted, and the temperature registers are not updated. The previous data is not changed and remains available.

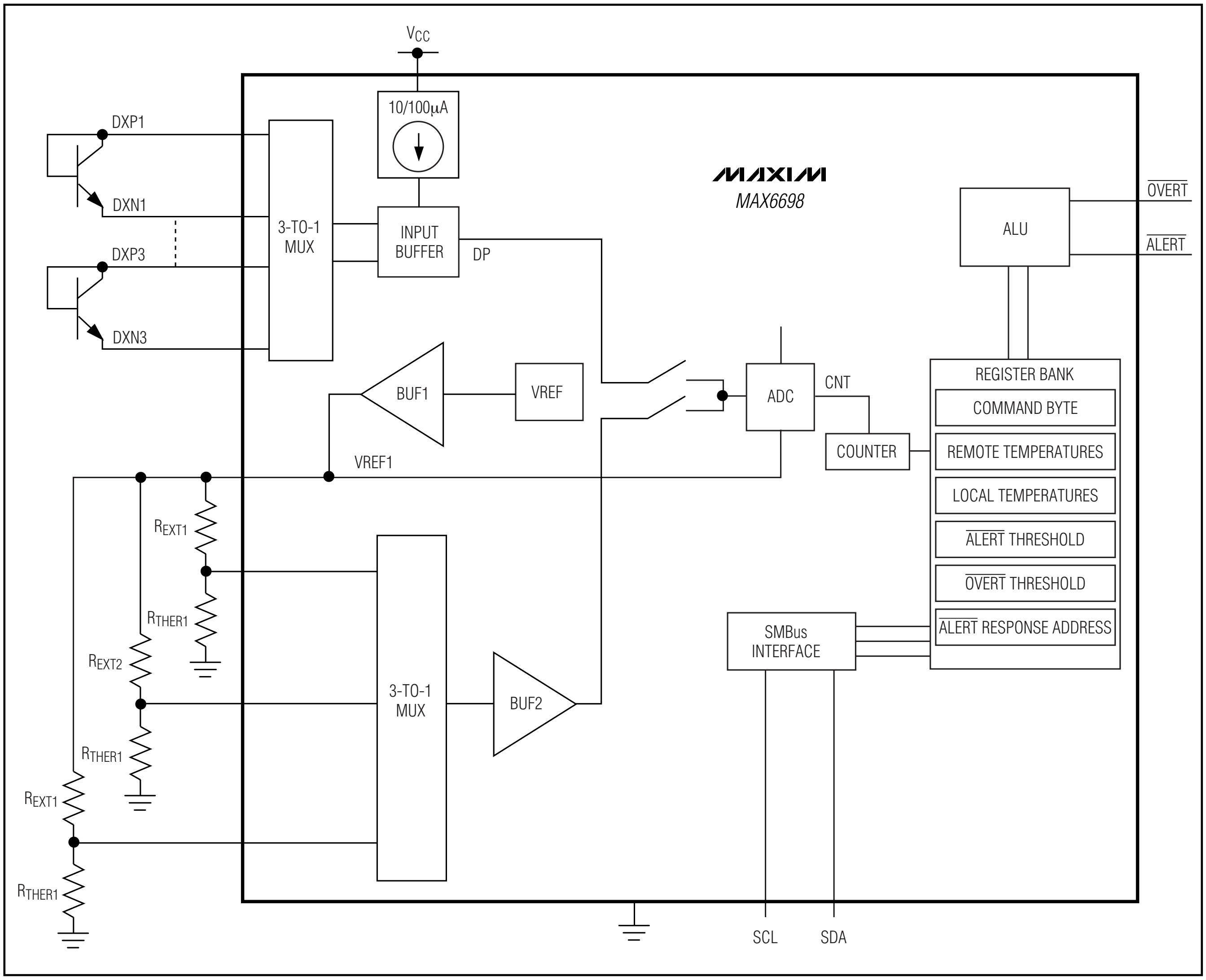


Figure 1. Internal Block Diagram

SMBus Digital Interface

From a software perspective, the MAX6698 appears as a series of 8-bit registers that contain temperature measurement data, alarm threshold values, and control bits. A standard SMBus-compatible 2-wire serial interface is used to read temperature data and write control bits and alarm threshold data. The same SMBus slave address also provides access to all functions.

The MAX6698 employs four standard SMBus protocols: write byte, read byte, send byte, and receive byte (Figure 2). The shorter receive byte protocol allows quicker transfers, provided that the correct data register was previously selected by a read byte instruction. Use caution with the shorter protocols in multimaster systems, since a second master could overwrite the command byte without informing the first master. Figure 3 is the SMBus write timing diagram and Figure 4 is the SMBus read timing diagram.

The remote diode 1 measurement channel provides 11 bits of data (1 LSB = 0.125°C). All other temperature-measurement channels provide 8 bits of temperature data (1 LSB = 1°C). The 8 most significant bits (MSBs) can be read from the local temperature, remote temperature, and thermistor registers. The remaining 3 bits

Write Byte Format

S	ADDRESS	WR	ACK	COMMAND	ACK	DATA	ACK	P
	7 bits			8 bits		8 bits		1

Slave Address: equivalent to chip-select line of a 3-wire interface

Command Byte: selects which register you are writing to

Data Byte: data goes into the register set by the command byte (to set thresholds, configuration masks, and sampling rate)

Read Byte Format

S	ADDRESS	WR	ACK	COMMAND	ACK	S	ADDRESS	RD	ACK	DATA	///	P
	7 bits			8 bits			7 bits			8 bits		

Slave Address: equivalent to chip-select line

Command Byte: selects which register you are reading from

Slave Address: repeated due to change in dataflow direction

Data Byte: reads from the register set by the command byte

Send Byte Format

S	ADDRESS	WR	ACK	COMMAND	ACK	P
	7 bits			8 bits		

Command Byte: sends command with no data, usually used for one-shot command

Receive Byte Format

S	ADDRESS	RD	ACK	DATA	///	P
	7 bits			8 bits		

Data Byte: reads data from the register commanded by the last read byte or write byte transmission; also used for SMBus alert response return address

S = Start condition *Shaded = Slave transmission*
P = Stop condition */// = Not acknowledged*

Figure 2. SMBus Protocols

for remote diode 1 can be read from the extended temperature register. If extended resolution is desired, the extended resolution register should be read first. This prevents the most significant bits from being overwritten by new conversion results until they have been read. If the most significant bits have not been read within an SMBus timeout period (nominally 25ms), normal updating continues. Table 1 shows themistor voltage data format. Table 2 shows the main temperature register (high byte) data format. Table 3 shows the extended resolution temperature register (low byte) data format.

Diode Fault Detection

If a channel's input DXP_ and DXN_ are left open, the MAX6698 detects a diode fault. An open diode fault does not cause either $\overline{\text{ALERT}}$ or $\overline{\text{OVERT}}$ to assert. A bit in the status register for the corresponding channel is set to 1 and the temperature data for the channel is stored as all 1s (FFh). It takes approximately 4ms for the MAX6698 to detect a diode fault. Once a diode fault is detected, the MAX6698 goes to the next channel in the conversion sequence. Depending on operating conditions, a shorted diode may or may not cause $\overline{\text{ALERT}}$ or $\overline{\text{OVERT}}$ to assert, so if a channel will not be used, disconnect its DXP and DXN inputs.

Table 1. Thermistor Voltage Data Format

V_{REXT}	DIGITAL OUTPUT
1.000	1100 1000
0.500	0110 0100
0.250	0011 0010
0.055	0000 1011
0.050	0000 1010
0.005	0000 0001
0.000	0000 0000

Alarm Threshold Registers

There are 11 alarm threshold registers that store overtemperature $\overline{\text{ALERT}}$ and $\overline{\text{OVERT}}$ threshold values. Seven of these registers are dedicated to store one local alert temperature threshold limit, three remote alert temperature threshold limits, and three thermistor voltage threshold limits (see the *$\overline{\text{ALERT}}$ Interrupt Mode* section). The remaining four registers are dedicated to remote-diode channel 1, and three thermistor channels 1, 2, and 3 to store overtemperature threshold limits (see the *$\overline{\text{OVERT}}$ Overtemperature Alarm* section). Access to these registers is provided through the SMBus interface.

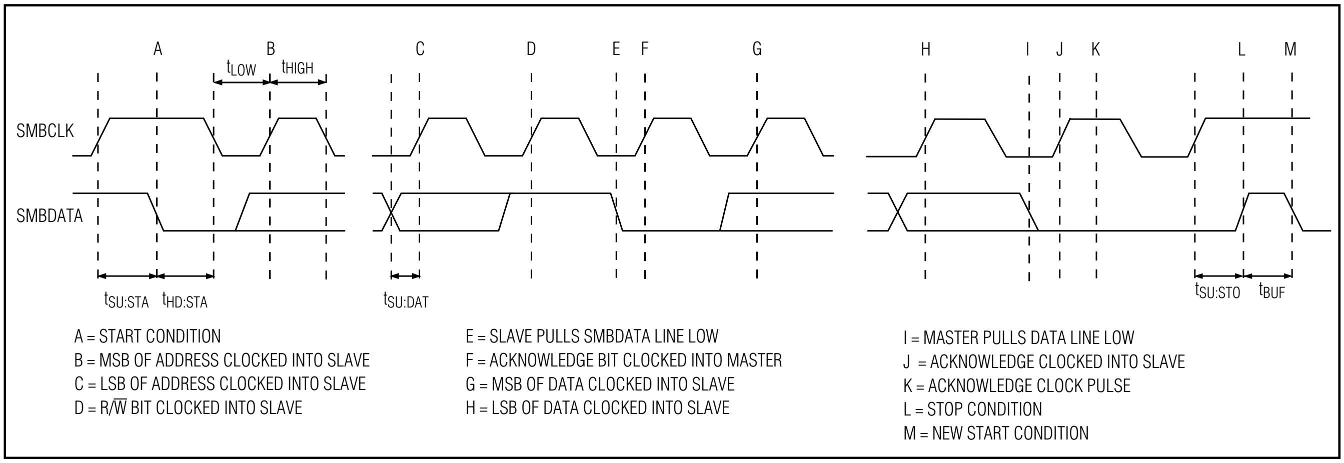


Figure 3. SMBus Write Timing Diagram

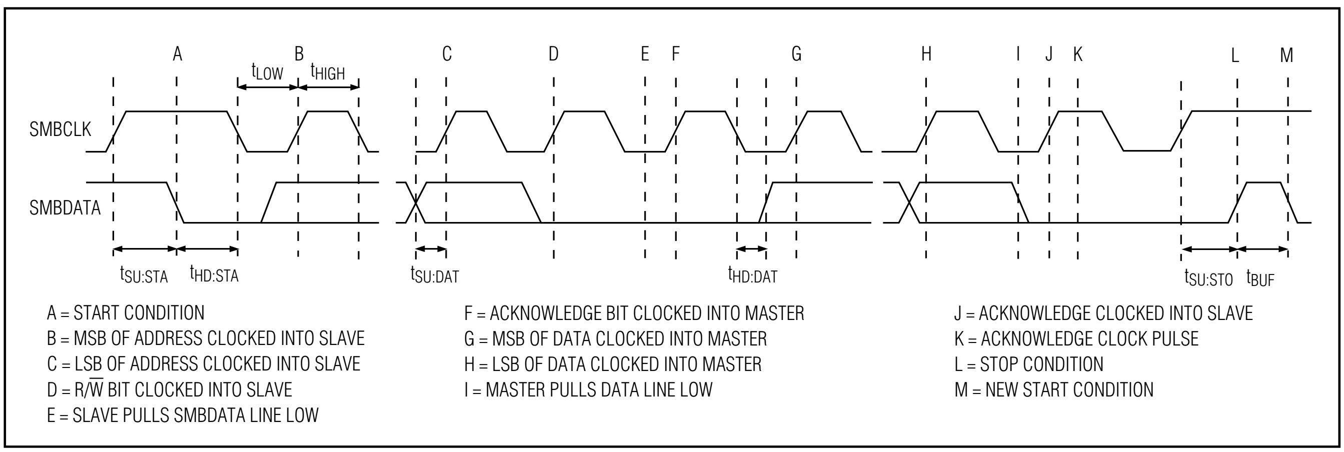


Figure 4. SMBus Read Timing Diagram

Table 2. Main Temperature Register (High Byte) Data Format

TEMP (°C)	DIGITAL OUTPUT
>127	0111 1111
127	0111 1111
126	0111 1110
25	00011001
0.00	0000 0000
<0.00	0000 0000
Diode fault (open)	1111 1111
Diode fault (short)	1111 1111 or 1110 1110

Table 3. Extended Resolution Temperature Register (Low Byte) Data Format

TEMP (°C)	DIGITAL OUTPUT
0	000X XXXX
+0.125	001X XXXX
+0.250	010X XXXX
+0.375	011X XXXX
+0.500	100X XXXX
+0.625	101X XXXX
+0.725	110X XXXX
+0.875	111X XXXX

ALERT Interrupt Mode

An ALERT interrupt occurs when the internal or external temperature reading exceeds a high-temperature limit (user programmable). The ALERT interrupt output signal can be cleared by reading the status register(s) associated with the fault(s) or by successfully responding to an alert response address transmission by the master. In both cases, the alert is cleared but is reasserted at the end of the next conversion if the fault condition still exists. The interrupt does not halt automatic conversions. The ALERT output is open drain so that multiple devices can share a common interrupt line. All ALERT interrupts can be masked using the configuration 3 register. The POR state of these registers is shown in Table 4.

ALERT Response Address

The SMBus alert response interrupt pointer provides quick fault identification for simple slave devices that lack the complex logic needed to be a bus master. Upon receiving an interrupt signal, the host master can broadcast a receive byte transmission to the alert response slave address (see the *Slave Addresses* section). Then, any slave device that generated an interrupt attempts to identify itself by putting its own address on the bus.

The alert response can activate several different slave devices simultaneously, similar to the I^{2}C General Call. If more than one slave attempts to respond, bus arbitration rules apply, and the device with the lower address code wins. The losing device does not generate an acknowledgment and continues to hold the ALERT line low until cleared. (The conditions for clearing an alert vary depending on the type of slave device.) Successful completion of the alert response protocol clears the output latch. If the condition that caused the alert still exists, the MAX6698 reasserts the ALERT interrupt at the end of the next conversion.

OVERT Overtemperature Alarms

The MAX6698 has four overtemperature registers that store remote alarm threshold data for the OVERT output. OVERT is asserted when a channel's measured temperature (voltage in the case of the thermistor channels) is greater than the value stored in the corresponding threshold register. OVERT remains asserted until the temperature drops below the programmed threshold minus 4°C hysteresis for remote-diode channel 1, or 4 LSB hysteresis for thermistor channels 1, 2, and 3. An overtemperature output can be used to activate a cooling fan, send a warning, initiate clock throttling, or trigger a system shutdown to prevent component damage. See Table 4 for the POR state of the overtemperature threshold registers.

Command Byte Functions

The 8-bit command byte register (Table 4) is the master index that points to the various other registers within the MAX6698. This register's POR state is 0000 0000.

Configuration Bytes Functions

There are three read-write configuration registers (Tables 5, 6, 7) that can be used to control the MAX6698's operation.

Configuration 1 Register

The configuration 1 register (Table 5) has several functions. Bit 7(MSB) is used to put the MAX6698 either in software standby mode (STOP) or continuous conversion mode. Bit 6 resets all registers to their power-on reset conditions and then clears itself. Bit 5 disables the SMBus timeout. Bit 4 enables more frequent conversions on channel 1, as described in the *ADC Conversion Sequence* section. Bit 3 enables resistance cancellation on channel 1. See the *Series Resistance Cancellation* section for more details. The remaining bits of the configuration 1 register are not used. The POR state of this register is 0000 0000 (00h).

Configuration 2 Register

The configuration 2 register functions are described in Table 6. Bits [6:0] are used to mask the ALERT interrupt output. Bit 6 masks the local alert interrupt, bits 5 through 3 mask the remote-diode ALERT interrupts, and bits 2 through 0 mask the thermistor alert interrupts. The power-up state of this register is 0000 0000 (00h).

Configuration 3 Register

Table 7 describes the configuration 3 register. Bits 5, 4, 3, and 0 mask the OVERT interrupt output for thermistor channels 1, 2, and 3 and remote-diode channel 1. The remaining bits, 7, 6, 2, and 1, are reserved. The power-up state of this register is 0000 0000 (00h).

Table 4. Command Byte Register Bit Assignment

REGISTER	ADDRESS (HEX)	POR STATE (HEX)	READ/ WRITE	DESCRIPTION
Local	07	00	R	Read local temperature register
Remote 1	01	00	R	Read channel 1 remote temperature register
Remote 2	02	00	R	Read channel 2 remote temperature register
Remote 3	03	00	R	Read channel 3 remote temperature register
Thermistor 1	04	00	R	Read thermistor 1 voltage register
Thermistor 2	05	00	R	Read thermistor 2 voltage register
Thermistor 3	06	00	R	Read thermistor 3 voltage register
Configuration 1	41	00	R/W	Read/write configuration register 1
Configuration 2	42	00	R/W	Read/write configuration register 2
Configuration 3	43	00	R/W	Read/write configuration register 3
Status 1	44	00	R	Read status register 1
Status 2	45	00	R	Read status register 2
Status 3	46	00	R	Read status register 3
Local $\overline{\text{ALERT}}$ High Limit	17	5A	R/W	Read/write local alert high-temperature threshold limit register
Remote 1 $\overline{\text{ALERT}}$ High Limit	11	6E	R/W	Read/write channel 1 remote-diode alert high-temperature threshold limit register
Remote 2 $\overline{\text{ALERT}}$ High Limit	12	7F	R/W	Read/write channel 2 remote-diode alert high-temperature threshold limit register
Remote 3 $\overline{\text{ALERT}}$ High Limit	13	64	R/W	Read/write channel 3 remote-diode alert high-temperature threshold limit register
Thermistor 1 $\overline{\text{ALERT}}$ High Limit	14	64	R/W	Read/write thermistor 1 voltage alert high-threshold limit register
Thermistor 2 $\overline{\text{ALERT}}$ High Limit	15	64	R/W	Read/write thermistor 2 alert high-threshold limit register
Thermistor 3 $\overline{\text{ALERT}}$ High Limit	16	64	R/W	Read/write thermistor 3 alert high-threshold limit register
Remote 1 $\overline{\text{OVERT}}$ High Limit	21	6E	R/W	Read/write channel 1 remote-diode overtemperature threshold limit register
Thermistor 1 $\overline{\text{OVERT}}$ High Limit	24	7F	R/W	Read/ write thermistor 1 overtemperature threshold limit register
Thermistor 2 $\overline{\text{OVERT}}$ High Limit	25	5A	R/W	Read/write thermistor 2 overtemperature threshold limit register
Thermistor 3 $\overline{\text{OVERT}}$ High Limit	26	5A	R/W	Read/write thermistor3 overtemperature threshold limit register
Remote 1 Extended Temperature	09	00	R	Read channel 1 remote-diode extended temperature register
Manufacturer ID	0A	4D	R	Read manufacturer ID
Device ID and Revision	0E	00	—	—

Table 5. Configuration 1 Register

BIT	NAME	POR STATE	FUNCTION
7(MSB)	STOP	0	Standby Mode Control Bit. If STOP is set to logic 1, the MAX6698 stops converting and enters standby mode.
6	POR	0	Reset Bit. Set to logic 1 to put the device into its power-on state. This bit is self-clearing.
5	$\overline{\text{TIMEOUT}}$	0	Timeout Enable Bit. Set to logic 0 to enable SMBus timeout.
4	Fast remote 1	0	Channel 1 Fast Conversion Bit. Set to logic 1 to enable fast conversion of channel 1.
3	Resistance cancellation	0	Resistance Cancellation Bit. When set to logic 1, the MAX6698 cancels series resistance in the channel 1 thermal diode.
2	Reserved	0	—
1	Reserved	0	—
0	Reserved	0	—

Table 6. Configuration 2 Register

BIT	NAME	POR STATE	FUNCTION
7(MSB)	Reserved	0	—
6	Mask Local ALERT	0	Local Alert Mask. Set to logic 1 to mask local channel $\overline{\text{ALERT}}$.
5	Mask Thermistor 3ALERT	0	Thermistor 3 Alert Mask. Set to logic 1 to mask thermistor 3 $\overline{\text{ALERT}}$.
4	Mask Thermistor 2ALERT	0	Thermistor 2 Alert Mask. Set to logic 1 to mask thermistor 2 $\overline{\text{ALERT}}$.
3	Mask Thermistor 1ALERT	0	Thermistor 1 Alert Mask. Set to logic 1 to mask thermistor 1 $\overline{\text{ALERT}}$.
2	Mask Remote-Diode 3ALERT	0	Remote-Diode 3 Alert Interrupt Mask. Set to logic 1 to mask remote diode 3 $\overline{\text{ALERT}}$.
1	Mask Remote-Diode 2ALERT	0	Remote-Diode 2 Alert Interrupt Mask. Set to logic 1 to mask remote diode 2 $\overline{\text{ALERT}}$.
0	Mask Remote-Diode 2ALERT	0	Remote-Diode 1 Alert Interrupt Mask. Set to logic 1 to mask remote diode 1 $\overline{\text{ALERT}}$.

Status Registers Functions

Status registers 1, 2, and 3 (Tables 8, 9, 10) indicate which (if any) temperature thresholds have been exceeded and if there is an open-circuit or short-circuit fault detected with the external sense junctions. Status register 1 indicates if the measured temperature has exceeded the threshold limit set in the $\overline{\text{ALERT}}$ registers for the local or remote-sensing diodes. Status register 2 indicates if the measured temperature has exceeded the threshold limit set in the $\overline{\text{OVERT}}$ registers. Status register 3 indicates if there is a diode fault (open or short) in any of the remote-sensing channels.

Bits in the alert status register clear by a successful read, but set again after the next conversion unless the fault is corrected, either by a drop in the measured temperature or an increase in the threshold temperature.

The $\overline{\text{ALERT}}$ interrupt output follows the status flag bit. Once the $\overline{\text{ALERT}}$ output is asserted, it can be deasserted by either reading status register 1 or by successfully responding to an alert response address. In both cases, the alert is cleared even if the fault condition exists, but the $\overline{\text{ALERT}}$ output reasserts at the end of the next conversion. Reading the status 2 register does not clear the $\overline{\text{OVERT}}$ interrupt output. To eliminate the fault condition,

Table 7. Configuration 3 Register

BIT	NAME	POR STATE	FUNCTION
7(MSB)	Reserved	0	—
6	Reserved	0	—
5	Mask Thermistor 3 $\overline{\text{OVERT}}$	0	Thermistor 3 $\overline{\text{OVERT}}$ Mask Bit. Set to logic 1 to mask thermistor 3 $\overline{\text{OVERT}}$.
4	Mask Thermistor 2 $\overline{\text{OVERT}}$	0	Thermistor 2 $\overline{\text{OVERT}}$ Mask Bit. Set to logic 1 to mask thermistor 2 $\overline{\text{OVERT}}$.
3	Mask Thermistor 1 $\overline{\text{OVERT}}$	0	Thermistor 1 $\overline{\text{OVERT}}$ Mask Bit. Set to logic 1 to mask thermistor 1 $\overline{\text{OVERT}}$.
2	Reserved	0	—
1	Reserved	0	—
0	Mask $\overline{\text{OVERT}}$ 1	0	Channel 1 Remote-Diode $\overline{\text{OVERT}}$ Mask Bit. Set to logic 1 to mask channel 1 $\overline{\text{OVERT}}$.

either the measured value must drop below the threshold minus the hysteresis value (4°C or 4 LSBs), or the trip threshold must be set at least 4°C (or 4 LSBs) above the current value.

Applications Information

Remote-Diode Selection

The MAX6698 directly measures the die temperature of CPUs and other ICs that have on-chip temperature-sensing diodes (see the *Typical Application Circuit*) or it can measure the temperature of a discrete diode-connected transistor.

Effect of Ideality Factor

The accuracy of the remote temperature measurements depends on the ideality factor (n) of the remote "diode" (actually a transistor). The MAX6698 is optimized for n = 1.008. A thermal diode on the substrate of an IC is normally a pnp with the base and emitter brought out the collector (diode connection) grounded. DXP_ must be connected to the anode (emitter) and DXN_ must be connected to the cathode (base) of this pnp. If a sense transistor with an ideality factor other than 1.008 is used, the output data is different from the data obtained with the optimum ideality factor. Fortunately, the difference is predictable. Assume a remote-diode sensor designed for a nominal ideality factor $n_{NOMINAL}$ is used to measure the temperature of a diode with a different ideality factor n1. The measured temperature T_M can be corrected using:

$$T_M = T_{ACTUAL}\left(\frac{n_1}{n_{NOMINAL}}\right)$$

where temperature is measured in Kelvin and $n_{NOMIMAL}$ for the MAX6698 is 1.008. As an example, assume you want to use the MAX6698 with a CPU that has an ideality factor of 1.002. If the diode has no series resistance, the measured data is related to the real temperature as follows:

$$T_{ACTUAL} = T_M \times \left(\frac{n_{NOMINAL}}{n_1}\right) = T_M \times \left(\frac{1.008}{1.002}\right) = T_M(1.00599)$$

For a real temperature of +85°C (358.15K), the measured temperature is +82.87°C (356.02K), an error of -2.13°C.

Series Resistance Cancellation

Some thermal diodes on high-power ICs can have excessive series resistance, which can cause temperature measurement errors with conventional remote temperature sensors. Channel 1 of the MAX6698 has a series resistance cancellation feature (enabled by bit 3 of the configuration 1 register) that eliminates the effect of diode series resistance. Set bit 3 to 1 if the series resistance is large enough to affect the accuracy of

Table 8. Status 1 Register

BIT	NAME	POR STATE	FUNCTION
7(MSB)	Reserved	0	—
6	Local ALERT	0	Local Channel High-Alert Bit. This bit is set to logic 1 when the local temperature exceeds the temperature threshold limit in the local ALERT high-limit register.
5	Thermistor 3 ALERT	0	Thermistor 3 Alert Bit. This bit is set to logic 1 when the thermistor 3 voltage exceeds the threshold limit in the thermistor 3 ALERT high-limit register.
4	Thermistor 2 ALERT	0	Thermistor 2 Alert Bit. This bit is set to logic 1 when the thermistor 2 voltage exceeds the threshold limit in the thermistor 2 ALERT high-limit register.
3	Thermistor 1 ALERT	0	Thermistor 1 Alert Bit. This bit is set to logic 1 when the thermistor 1 voltage exceeds the threshold limit in the thermistor 1 ALERT high-limit register.
2	Remote-Diode 3 ALERT	0	Channel 3 Remote-Diode High-Alert Bit. This bit is set to logic 1 when the channel 3 remote-diode temperature exceeds the programmed temperature threshold limit in the remote 3 ALERT high-limit register.
1	Remote-Diode 2 ALERT	0	Channel 2 Remote-Diode High-Alert Bit. This bit is set to logic 1 when the channel 2 remote-diode temperature exceeds the temperature threshold limit in the remote 2 ALERT high-limit register.
0	Remote-Diode 1 ALERT	0	Channel 1 Remote-Diode High-Alert Bit. This bit is set to logic 1 when the channel 1 remote-diode temperature exceeds the temperature threshold limit in the remote 1 ALERT high-limit register.

channel 1. The series resistance cancellation function increases the conversion time for channel 1 by 125ms. This feature cancels the bulk resistance of the sensor and any other resistance in series (wire, contact resistance, etc.). The cancellation range is from 0 to 100Ω.

Discrete Remote Diodes

When the remote-sensing diode is a discrete transistor, its collector and base must be connected together. Table 11 lists examples of discrete transistors that are appropriate for use with the MAX6698. The transistor must be a small-signal type with a relatively high forward voltage; otherwise, the A/D input voltage range can be violated. The forward voltage at the highest expected temperature must be greater than 0.25V at 10µA, and at the lowest expected temperature, the forward voltage must be less than 0.95V at 100µA. Large power transistors must not be used. Also, ensure that the base resistance is less than 10Ω. Tight specifications for forward current gain ($50 < \beta < 150$, for example) indicate that the manufacturer has good process controls and that the devices have consistent V_{BE} characteristics. Manufacturers of discrete transistors do not normally specify or guarantee ideality factor. This is normally not a problem since good-quality discrete transistors tend to have ideality factors that fall within a relatively narrow range. We have observed variations in remote temperature readings of less than ±2°C with a variety of discrete transistors. Still, it is good design practice to verify good consistency of temperature readings with several discrete transistors from any manufacturer under consideration.

Unused Diode Channels

If one or more of the remote diode channels is not needed, the DXP and DXN inputs for that channel should either be unconnected, or the DXP input should be connected to V_{CC}. The status register indicates a diode "fault" for this channel and the channel is ignored during the temperature-measurement sequence. It is also good practice to mask any unused channels immediately upon power-up by setting the appropriate bits in the Configuration 2 and Configuration 3 registers. This will prevent unused channels from causing ALERT# or OVERT# to assert.

Thermistor Measurements

The MAX6698 can use three external thermistors to measure temperature. A thermistor's resistance varies as a function of temperature. A negative temperature coefficient (NTC) thermistor can be connected between the thermistor input and ground, with a series resistor, REXT_, connected from the thermistor input to VREF.

Table 9. Status 2 Register

BIT	NAME	POR STATE	FUNCTION
7(MSB)	Reserved	0	—
6	Reserved	0	—
5	Thermistor 3 OVERT	0	Thermistor 3 Overtemperature Status Bit. This bit is set to logic 1 when the thermistor 3 voltage exceeds the threshold limit in the thermistor 3 OVERT high-limit register.
4	Thermistor 2 OVERT	0	Thermistor 2 Overtemperature Status Bit. This bit is set to logic 1 when the thermistor 2 voltage exceeds the threshold limit in the thermistor 2 OVERT high-limit register.
3	Thermistor 1 OVERT	0	Thermistor 1 Overtemperature Status Bit. This bit is set to logic 1 when the thermistor 1 voltage exceeds the threshold limit in the thermistor 1 OVERT high-limit register.
2	Reserved	0	—
1	Reserved	0	—
0	Remote 1 OVERT	0	Channel 1 Remote-Diode Overtemperature Status Bit. This bit is set to logic 1 when the channel 1 remote-diode temperature exceeds the temperature threshold limit in the remote 1 OVERT high-limit register.

Table 10. Status 3 Register

BIT	NAME	POR STATE	FUNCTION
7(MSB)	Reserved	0	—
6	Reserved	0	—
5	Reserved	0	—
4	Reserved	0	—
3	Diode fault 3	0	Channel 3 Remote-Diode Fault Bit. This bit is set to 1 when DXP3 and DXN3 are open circuit or when DXP3 is connected to V_{CC}.
2	Diode fault 2	0	Channel 2 Remote-Diode Fault Bit. This bit is set to 1 when DXP2 and DXN2 are open circuit or when DXP2 is connected to V_{CC}.
1	Diode fault 1	0	Channel 1 Remote-Diode Fault Bit. This bit is set to 1 when DXP1 and DXN1 are open circuit or when DXP1 is connected to V_{CC}.
0	Reserved	0	—

7-Channel Precision Remote-Diode, Thermistor, and Local Temperature Monitor

Table 11. Remote-Sensors Transistor Manufacturers

MANUFACTURER	MODEL NO.
Central Semiconductor (USA)	CMPT3904
Rohm Semiconductor (USA)	SST3904
Samsung (Korea)	KST3904-TF
Siemens (Germany)	SMBT3904
Zetex (England)	FMMT3904CT-ND

Note: *Discrete transistors must be diode connected (base shorted to collector).*

Slave Addresses

Table 12 lists the MAX6698 slave addresses.

Table 12. Slave Address

PART	SMBus SLAVE ID	PIN-PACKAGE
MAX6698EE34	0011 010	16 QSOP
MAX6698EE38	0011 100	16 QSOP
MAX6698EE99	1001 100	16 QSOP
MAX6698EE9C	1001 110	16 QSOP
MAX6698UE34	0011 010	16 TSSOP
MAX6698UE38	0011 100	16 TSSOP
MAX6698UE99	1001 100	16 TSSOP
MAX6698UE9C	1001 110	16 TSSOP

VREF supplies a reference voltage (1V nominal) to bias the thermistor/REXT_ voltage-divider. The voltage across REXT is measured by the MAX6698's ADC, resulting in a voltage that is directly proportional to temperature. The data in the thermistor registers gives the voltage across REXT as a fraction of the reference voltage (1LSB = 0.5% of VREF).

Because thermistors have nonlinear temperature-resistance functions, and because different thermistors have different functions, it is important to understand the relationship between temperature, REXT, and the voltage across REXT for a given thermistor. Table 13 shows temperature vs. the thermistor channel data for a Betatherm 10k3A1 thermistor and REXT=1600Ω.

Thermal Mass and Self-Heating

When sensing local temperature, the MAX6698 measures the temperature of the printed-circuit board (PCB) to which it is soldered. The leads provide a good thermal path between the PCB traces and the die. As with all IC temperature sensors, thermal conductivity between the die and the ambient air is poor by comparison, making air temperature measurements impractical. Because the thermal mass of the PCB is far greater than that of the MAX6698, the device follows temperature changes on the PCB with little or no perceivable delay. When measuring the temperature of a CPU or other IC with an on-chip sense junction, thermal mass has virtually no effect; the measured temperature of the junction tracks the actual temperature within a conversion cycle.

When measuring temperature with discrete remote transistors, the best thermal response times are obtained with transistors in small packages (i.e., SOT23 or SC70). Take care to account for thermal gradients between the heat source and the sensor, and ensure that stray air currents across the sensor package do not interfere with measurement accuracy. Self-heating does not significantly affect measurement accuracy. Remote-sensor self-heating due to the diode current source is negligible.

ADC Noise Filtering

The integrating ADC has good noise rejection for low-frequency signals such as power-supply hum. In environments with significant high-frequency EMI, connect an external 2200pF capacitor between DXP_ and DXN_. Larger capacitor values can be used for added filtering, but do not exceed 3300pF because it can introduce errors due to the rise time of the switched current source. High-frequency noise reduction is needed for high-accuracy remote measurements. Noise can be reduced with careful PCB layout as discussed in the *PCB Layout* section.

PCB Layout

Follow these guidelines to reduce the measurement error when measuring remote temperature:

1) Place the MAX6698 as close as is practical to the remote diode. In noisy environments, such as a computer motherboard, this distance can be 4in to 8in (typ). This length can be increased if the worst noise sources are avoided. Noise sources include CRTs, clock generators, memory buses, and PCI buses.
2) Do not route the DXP-DXN lines next to the deflection coils of a CRT. Also, do not route the traces across fast digital signals, which can easily introduce +30°C error, even with good filtering.

3) Route the DXP and DXN traces in parallel and in close proximity to each other. Each parallel pair of traces should go to a remote diode. Route these traces away from any higher voltage traces, such as +12VDC. Leakage currents from PCB contamination must be dealt with carefully since a 20MΩ leakage path from DXP to ground causes about +1°C error. If high-voltage traces are unavoidable, connect guard traces to GND on either side of the DXP-DXN traces (Figure 5).
4) Route through as few vias and crossunders as possible to minimize copper/solder thermocouple effects.
5) Use wide traces when practical.
6) When the power supply is noisy, add a resistor (up to 47Ω) in series with V_{CC}.

Twisted-Pair and Shielded Cables

Use a twisted-pair cable to connect the remote sensor for remote-sensor distances longer than 8in or in very noisy environments. Twisted-pair cable lengths can be between 6ft and 12ft before noise introduces excessive errors. For longer distances, the best solution is a shielded twisted pair like that used for audio microphones. For example, Belden #8451 works well for distances up to 100ft in a noisy environment. At the device, connect the twisted pair to DXP and DXN and the shield to GND. Leave the shield unconnected at the remote sensor. For very long cable runs, the cable's parasitic capacitance often provides noise filtering, so the 2200pF capacitor can often be removed or reduced in value. Cable resistance also affects remote-sensor accuracy. For every 1Ω of series resistance the error is approximately +1/2°C.

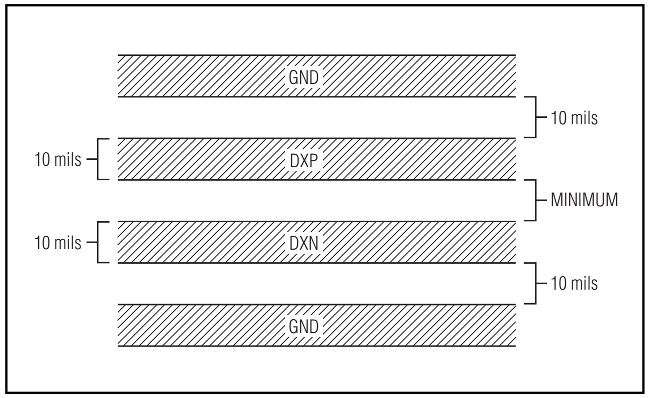


Figure 5. Recommended DXP-DXN PCB Traces

Table 13. Temperature vs. Thermistor Channel Data for a Betatherm 103A1 Thermistor and R_{EXT} = 1600Ω

T (°C)	R_{THERM}	V_{REXT}	CODE (DECIMAL)	BINARY CODE	HEX CODE
-20	96974	0.016231	3	11000000	3
-19	91525	0.017181	3	11000000	3
-18	86415	0.018179	4	10000000	4
-17	81621	0.019226	4	10000000	4
-16	77121	0.020325	4	10000000	4
-15	72895	0.021478	4	10000000	4
-14	68927	0.022686	5	10100000	5
-13	65198	0.023953	5	10100000	5
-12	61693	0.025279	5	10100000	5
-11	58397	0.026668	5	10100000	5
-10	55298	0.02812	6	11000000	6
-9	52380	0.029641	6	11000000	6
-8	49633	0.03123	6	11000000	6
-7	47047	0.03289	7	11100000	7
-6	44610	0.034625	7	11100000	7
-5	42314.6	0.036434	7	11100000	7
-4	40149.5	0.038324	8	10000000	8
-3	38108.5	0.040294	8	10000000	8
-2	36182.8	0.042347	8	10000000	8
-1	34366.1	0.044486	9	10010000	9
0	32650.8	0.046714	9	10010000	9
1	31030.4	0.049034	10	10100000	A
2	29500.1	0.051447	10	10100000	A
3	28054.2	0.053955	11	10110000	B
4	26687.6	0.056562	11	10110000	B
5	25395.5	0.059269	12	11000000	C
6	24172.7	0.062081	12	11000000	C
7	23016	0.064998	13	11010000	D
8	21921.7	0.068022	14	11100000	E
9	20885.2	0.071158	14	11100000	E
10	19903.5	0.074406	15	11110000	F
11	18973.6	0.07777	16	10000000	10
12	18092.6	0.081249	16	10000000	10
13	17257.4	0.084847	17	10001000	11
14	16465.1	0.088569	18	10010000	12
15	15714	0.092411	18	10010000	12
16	15001.2	0.096379	19	10011000	13
17	14324.6	0.100473	20	10100000	14
18	13682.6	0.104694	21	10101000	15

Table 13. Temperature vs. Thermistor Channel Data for a Betatherm 103A1 Thermistor and R_{EXT} = 1600Ω (continued)

T (°C)	R_{THERM}	V_{REXT}	CODE (DECIMAL)	BINARY CODE	HEX CODE
19	13072.8	0.109045	22	10110000	16
20	12493.7	0.113526	23	10111000	17
21	11943.3	0.11814	24	11000000	18
22	11420	0.122888	25	11001000	19
23	10922.7	0.127768	26	11010000	1A
24	10449.9	0.132781	27	11011000	1B
25	10000	0.137931	28	11100000	1C
26	9572	0.143215	29	11101000	1D
27	9164.7	0.148634	30	11110000	1E
28	8777	0.154187	31	11111000	1F
29	8407.7	0.159877	32	10000000	20
30	8056	0.1657	33	10000100	21
31	7720.9	0.171657	34	10001000	22
32	7401.7	0.177744	36	10010000	24
33	7097.2	0.183967	37	10010100	25
34	6807	0.190318	38	10011000	26
35	6530.1	0.1968	39	10011100	27
36	6266.1	0.203404	41	10100100	29
37	6014.2	0.210134	42	10101000	2A
38	5773.7	0.216987	43	10101100	2B
39	5544.1	0.223961	45	10110100	2D
40	5324.9	0.23105	46	10111000	2E
41	5115.6	0.238251	48	11000000	30
42	4915.5	0.245568	49	11000100	31
43	4724.3	0.252992	51	11001100	33
44	4541.6	0.260518	52	11010000	34
45	4366.9	0.268146	54	11011000	36
46	4199.9	0.275867	55	11011100	37
47	4040.1	0.283683	57	11100100	39
48	3887.2	0.291588	58	11101000	3A
49	3741.1	0.299564	60	11110000	3C
50	3601	0.307633	62	11111000	3E
51	3466.9	0.315775	63	11111100	3F
52	3338.6	0.323978	65	10000010	41
53	3215.6	0.332254	66	10000100	42
54	3097.9	0.340578	68	10001000	44
55	2985.1	0.348956	70	10001100	46
56	2876.9	0.35739	71	10001110	47
57	2773.2	0.365865	73	10010010	49

Table 13. Temperature vs. Thermistor Channel Data for a Betatherm 103A1 Thermistor and R_{EXT} = 1600Ω (continued)

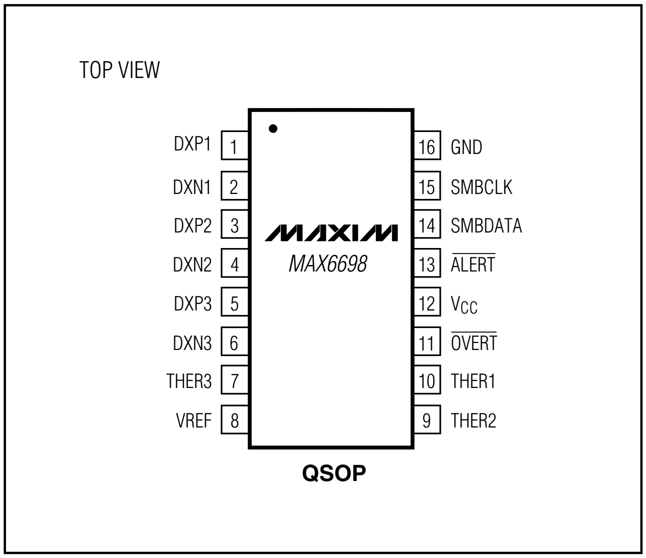
T (°C)	R_{THERM}	V_{REXT}	CODE (DECIMAL)	BINARY CODE	HEX CODE
58	2673.9	0.374365	75	10010110	4B
59	2578.5	0.382913	77	10011010	4D
60	2487.1	0.391476	78	10011100	4E
61	2399.4	0.40006	80	10100000	50
62	2315.2	0.408664	82	10100100	52
63	2234.7	0.417243	83	10100110	53
64	2156.7	0.425906	85	10101010	55
65	2082.3	0.434511	87	10101110	57
66	2010.8	0.443115	89	10110010	59
67	1942.1	0.451709	90	10110100	5A
68	1876	0.460299	92	10111000	5C
69	1812.6	0.468851	94	10111100	5E
70	1751.6	0.477384	95	10111110	5F
71	1693	0.485879	97	11000010	61
72	1636.63	0.494341	99	11000010	63
73	1582.41	0.502764	101	11001010	65
74	1530.28	0.511136	102	11001100	66
75	1480.12	0.51946	104	11010000	68
76	1431.87	0.527727	106	11010100	6A
77	1385.37	0.535947	107	11010110	6B
78	1340.68	0.544092	109	11011010	6D
79	1297.64	0.552173	110	11011100	6E
80	1256.17	0.560191	112	11100000	70
81	1216.23	0.568135	114	11100100	72
82	1177.75	0.576006	115	11100110	73
83	1140.71	0.58379	117	11101010	75
84	1104.99	0.591499	118	11101100	76
85	1070.58	0.599121	120	11110000	78
86	1037.4	0.606658	121	11110010	79
87	1005.4	0.614109	123	11110110	7B
88	974.56	0.621465	124	11111000	7C
89	944.81	0.628731	126	11111100	7E
90	916.11	0.635902	127	11111110	7F
91	888.41	0.642981	129	10000001	81
92	861.7	0.649957	130	10000010	82

Table 13. Temperature vs. Thermistor Channel Data for a Betatherm 103A1 Thermistor and R_{EXT} = 1600Ω (continued)

T (°C)	R_{THERM}	V_{REXT}	CODE (DECIMAL)	BINARY CODE	HEX CODE
93	835.93	0.656833	131	10000011	83
94	811.03	0.663617	133	10000101	85
95	786.99	0.6703	134	10000110	86
96	763.79	0.676879	135	10000111	87
97	741.38	0.683358	137	10001001	89
98	719.74	0.689732	138	10001010	8A
99	698.82	0.696009	139	10001011	8B
100	678.63	0.702176	140	10001100	8C
101	659.1	0.708247	142	10001110	8E
102	640.23	0.714212	143	10001111	8F
103	622	0.720072	144	10010000	90
104	604.36	0.725834	145	10010001	91
105	587.31	0.731492	146	10010010	92
106	570.82	0.737049	147	10010011	93
107	554.86	0.742508	149	10010101	95
108	539.44	0.747859	150	10010110	96
109	524.51	0.753115	151	10010111	97
110	510.06	0.758272	152	10011000	98
111	496.08	0.76333	153	10011001	99
112	482.55	0.768289	154	10011010	9A
113	469.45	0.773152	155	10011011	9B
114	456.76	0.777923	156	10011100	9C
115	444.48	0.782595	157	10011101	9D
116	432.58	0.787177	157	10011101	9D
117	421.06	0.791664	158	10011110	9E
118	409.9	0.79606	159	10011111	9F
119	399.08	0.800368	160	10100000	A0
120	388.59	0.80459	161	10100001	A1
121	378.44	0.808718	162	10100010	A2
122	368.59	0.812764	163	10100011	A3
123	359.05	0.816722	163	10100011	A3
124	349.79	0.820601	164	10100100	A4
125	340.82	0.824394	165	10100101	A5
126	332	0.828157	166	10100110	A6
127	323.5	0.831817	166	10100110	A6

7-Channel Precision Remote-Diode, Thermistor, and Local Temperature Monitor

Pin Configuration



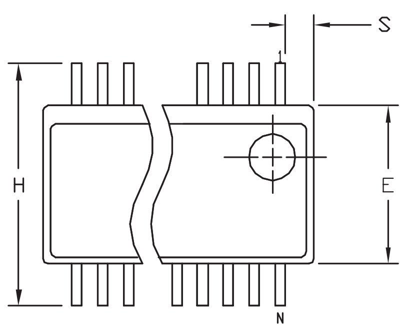
Chip Information

PROCESS: BiCMOS

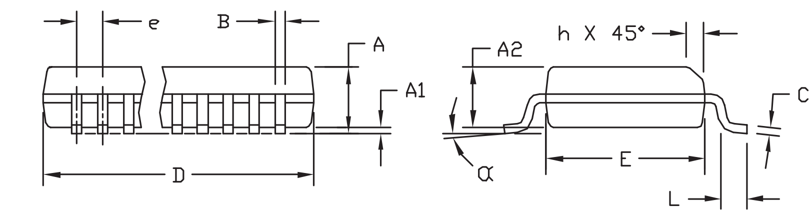
Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)

QSOP.EPS



	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	.053	.069	1.35	1.75
A1	.004	.010	.102	.254
A2	.049	.065	1.245	1.651
B	.008	.012	0.20	0.30
C	.0075	.0098	0.191	0.249
D	SEE VARIATIONS			
E	.150	.157	3.81	3.99
e	.025 BSC		0.635 BSC	
H	.230	.244	5.84	6.20
h	.010	.016	0.25	0.41
L	.016	.035	0.41	0.89
N	SEE VARIATIONS			
α	0°	8°	0°	8°



VARIATIONS:

	INCHES		MILLIMETERS			
	MIN.	MAX.	MIN.	MAX.	N	
D	.189	.196	4.80	4.98	16	AB
S	.0020	.0070	0.05	0.18		
D	.337	.344	8.56	8.74	20	AD
S	.0500	.0550	1.270	1.397		
D	.337	.344	8.56	8.74	24	AE
S	.0250	.0300	0.635	0.762		
D	.386	.393	9.80	9.98	28	AF
S	.0250	.0300	0.635	0.762		

NOTES:

1). D & E DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
2). MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .006" PER SIDE.
3). CONTROLLING DIMENSIONS: INCHES.
4). MEETS JEDEC MO137.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

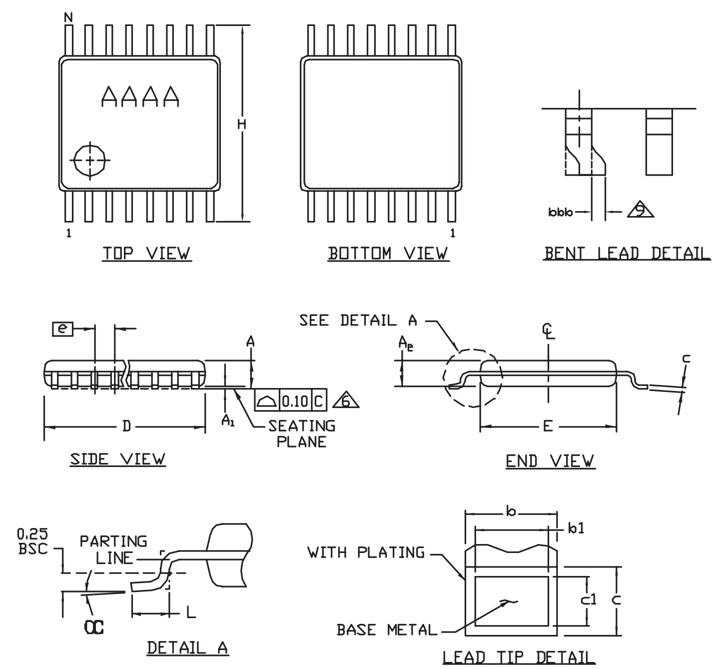
TITLE: PACKAGE OUTLINE, QSOP .150", .025" LEAD PITCH

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0055	F	1/1

7-Channel Precision Remote-Diode, Thermistor, and Local Temperature Monitor

Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)



SYMBOL	COMMON DIMENSIONS			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	—	1.10		.043
A_1	0.05	0.15	.002	.006
A_2	0.85	0.95	.033	.037
b	0.19	0.30	.007	.012
b_1	0.19	0.25	.007	.010
c	0.09	0.20	.004	.008
c_1	0.09	0.14	.004	.006
D	SEE VARIATIONS		SEE VARIATIONS	
E	4.30	4.50	.169	.177
e	0.65 BSC		.026 BSC	
H	6.25	6.55	.246	.258
L	0.50	0.70	.020	.028
N	SEE VARIATIONS		SEE VARIATIONS	
α	0°	8°	0°	8°
bbb	0.10 MAX			

JEDEC MO-153	N		PKG. CODES	VARIATIONS			
				MILLIMETERS		INCHES	
				MIN.	MAX.	MIN.	MAX.
AB-1	14	D	U14-1, U14-2	4.90	5.10	.193	.201
AB	16	D	U16-1, U16-2	4.90	5.10	.193	.201
AC	20	D	U20-2, U20-3	6.40	6.60	.252	.260
AD	24	D	U24-1	7.70	7.90	.303	.311
AE	28	D	U28-1, U28-2, U28-3	9.60	9.80	.378	.386

NOTES
1. DIMENSIONS D AND E DO NOT INCLUDE FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm PER SIDE
3. CONTROLLING DIMENSION: MILLIMETER
4. MEETS JEDEC OUTLINE MO-153. SEE JEDEC VARIATIONS TABLE
5. "N" REFERS TO NUMBER OF LEADS
6. LEAD COPLANARITY 0.10 MM MAX.
7. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY
8. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY
9. BENT LEAD 0.10 MM MAX.

-DRAWING NOT TO SCALE-

DALLAS SEMICONDUCTOR MAXIM

TITLE: PACKAGE OUTLINE, TSSOP 4.40mm BODY

APPROVAL | DOCUMENT CONTROL NO. 21-0066 | REV. I | 1/1

TSSOP4.40mm.EPS

Revision History

Pages changed at Rev 2: 1, 2, 24

Pages changed at Rev 3: 1, 5, 8, 9, 10, 14–17, 24