MIC280

Precision IttyBitty Thermal Supervisor

Features

- Measures Local and Remote Temperature
- Highly Accurate Remote Sensing: ±1°C max., +60°C to +100°C
- Superior Noise Immunity for Reduced Temperature Guardbands
- 9-bit to 12-bit Temperature Resolution for Remote Zone
- Fault Queues to Further Reduce Nuisance Tripping
- Programmable High, Low, and Overtemperature Thresholds for Each Zone
- SMBus 2.0-Compatible Serial Interface Including Device Timeout to Prevent Bus Lockup
- Voltage-Tolerant I/Os
- Open-Drain Interrupt Output Pin Supports SMBus Alert Response Address Protocol
- Low Power Shutdown Mode
- Locking of Critical Functions to Ensure Failsafe Operation
- Failsafe Response to Diode Faults
- Enables ACPI-Compliant Thermal Management
- 3.0V to 3.6V Power Supply Range
- Available in IttyBitty SOT23-6 Package

Applications

- Desktop, Server, and Notebook Computers
- Printers and Copiers
- Test and Measurement Equipment
- Thermal Supervision of Xilinx Virtex FPGAs
- Wireless/RF Systems
- Intelligent Power Supplies
- Datacom/Telecom Cards

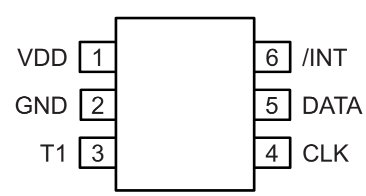
General Description

The MIC280 is a digital thermal supervisor capable of measuring its own internal temperature and that of a remote PN junction. The remote junction may be an inexpensive commodity transistor (e.g., 2N3906) or an embedded thermal diode such as those found in Intel Pentium® II/III/IV CPUs, AMD Athlon® CPUs, and Xilinx Virtex® FPGAs. A 2-wire SMBus® 2.0-compatible serial interface is provided for host communication. Remote temperature is measured with ±1°C accuracy and 9-bit to 12-bit resolution (programmable). Independent high, low, and overtemperature thresholds are provided for each zone.

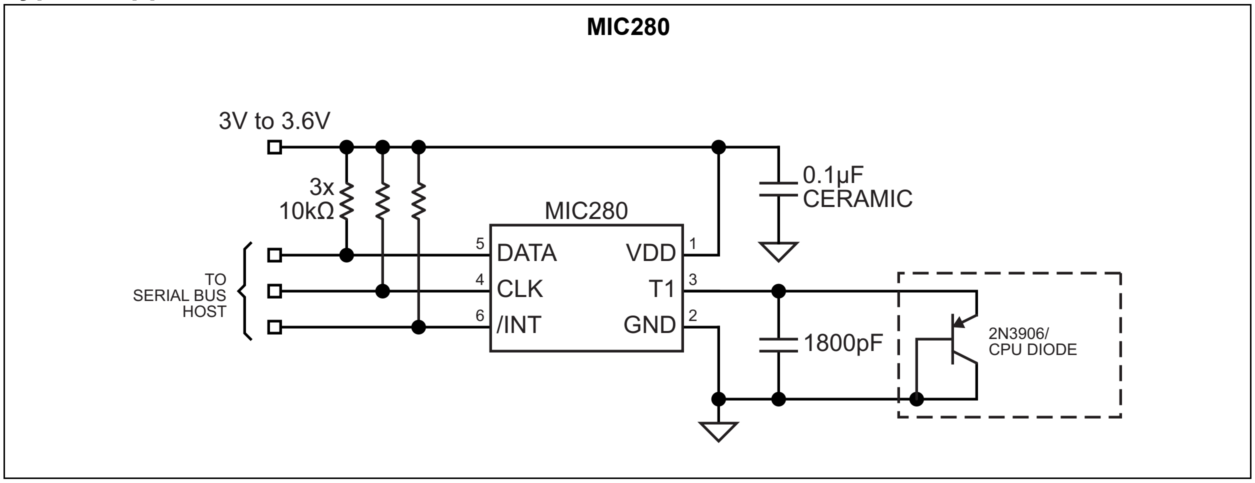
The advanced integrating A/D converter and analog front-end reduce errors due to noise for maximum accuracy and minimum guardbanding. The interrupt output signals temperature events to the host, including data-ready and diode faults. Critical device settings can be locked to prevent changes and ensure failsafe operation. The clock, data, and interrupt pins are 5V-tolerant regardless of the value of V_{DD}. They will not clamp the bus lines low even if the device is powered down. Superior accuracy, failsafe operation, and small size make the MIC280 an excellent choice for the most demanding thermal management applications.

Package Type

MIC280
SOT23-6 (M6)



Typical Application Circuit



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Power Supply Voltage (V_{DD})....................+3.8V
Voltage on T1....................–0.3V to V_{DD} + 0.3V
Voltage on CLK, DATA, /INT....................–0.3V to +6V
Current into any Pin....................±10 mA
Power Dissipation (T_A = +125°C)....................109 mW
ESD Rating (Human Body Model, Note 1)....................1.5 kV
ESD Rating (Machine Model, Note 1)....................200V

Operating Ratings ‡

Power Supply Voltage (V_{DD})....................+3.0V to +3.6V

† Notice: Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

‡ Notice: The device is not guaranteed to function outside its operating ratings. Final test on outgoing product is performed at T_A = +25°C.

Note 1: Devices are ESD sensitive. Handling precautions are recommended. Human body model, 1.5 kΩ in series with 100 pF.

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: V_{DD} = 3.3V; T_A = 25°C, unless noted. **Bold** values indicate –55°C ≤ T_A ≤ +125°C, 3.0V ≤ V_{DD} ≤ 3.6V, unless noted. (**Note 1**, **Note 2**, **Note 3**).

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Power Supply						
Supply Current	I_{DD}	—	0.23	**0.4**	mA	/INT, T1 open; CLK = DATA = High; Normal mode
		—	9	—	µA	Shutdown mode; /INT, T1 open; Note 3 CLK = 100 kHz, DATA = High
		—	6	—	µA	Shutdown mode; /INT, T1 open; CLK = DATA = High
Power-On Reset Time Note 3	t_{POR}	—	200	—	µs	V_{DD} > V_{POR}
Power-On Reset Voltage	V_{POR}	—	2.65	**2.95**	V	All registers reset to default values; A/D conversions initiated
Power-on Reset Hysteresis Voltage Note 3	V_{HYST}	—	300	—	mV	—
Temperature-to-Digital Converter Characteristics						
Accuracy, Remote Temperature Note 4, Note 6, Note 9, Note 10	—	—	±0.25	**±1**	°C	60°C ≤ T_D ≤ 100°C 3.15V < V_{DD} < 3.45V, 25°C < T_A < 85°C
		—	±1	**±2**	°C	0°C ≤ T_D ≤ 100°C 3.15V < V_{DD} < 3.45V, 25°C < T_A < 85°C
		—	±2	**±4**	°C	–55°C ≤ T_D ≤ 125°C 3.15V < V_{DD} < 3.45V, 25°C < T_A < 85°C
Accuracy, Local Temperature Note 4, Note 9	—	—	±1	**±2**	°C	0°C ≤ T_A ≤ 100°C, 3.15V < V_{DD} < 3.45V
		—	**±1.5**	**±2.5**	°C	–55°C ≤ T_A ≤ 125°C, 3.15V < V_{DD} < 3.45V
Conversion Time Note 4, Note 7	t_{CONV}	—	200	**240**	ms	RES[1:0]=00 (9 bits)
		—	**330**	**390**	ms	RES[1:0]=01 (10 bits)
		—	570	**670**	ms	RES[1:0]=10 (11 bits)
		—	**1000**	**1250**	ms	RES[1:0]=11 (12 bits)

Note 1: Specification for packaged product only.

2: Current into the /INT or DATA pins will result in self heating of the device. Sink current should be minimized for best accuracy.

3: Guaranteed by design over the operating temperature range. Not 100% production tested.

4: The device is not guaranteed to function outside its operating ratings. Final test on outgoing product is performed at TA = 25°C.

5: t_{INT} and t_{CRIT} are equal to t_{CONV}.

6: T_D is the temperature of the remote diode junction. Testing is performed using a single unit of one of the transistors listed in Table 8.

7: $t_{CONV} = t_{CONV(local)} + t_{CONV(remote)}$. Following the acquisition of either remote or local temperature data, the limit comparisons for that zone are performed and the device status updated. Status bits will be set and /INT driven active, if applicable.

8: The interrupt reset propagation delay is dominated by the capacitance on the bus.

9: Accuracy specification does not include quantization noise, which may be up to ±1/2 LSB.

10: Tested at 10-bit resolution.

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: V_{DD} = 3.3V; T_A = 25°C, unless noted. **Bold** values indicate –55°C ≤ T_A ≤ +125°C, 3.0V ≤ V_{DD} ≤ 3.6V, unless noted. (**Note 1**, **Note 2**, **Note 3**).

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Remote Temperature Input, T1						
Current into External Diode, Note 3	I_F	—	**192**	**400**	µA	T1 forced to 1.0V, High level
		7	12	—	µA	Low level
Serial Data I/O Pin, DATA						
Low Output Voltage, Note 2	V_{OL}	—	—	**0.3**	V	I_{OL} = 3 mA
		—	—	**0.5**	V	I_{OL} = 6 mA
Low Input Voltage	V_{IL}	—	—	**0.8**	V	3V ≤ V_{DD} ≤ 3.6V
High Input Voltage	V_{IH}	**2.1**	—	**5.5**	V	3V ≤ V_{DD} ≤ 3.6V
Input Capacitance	C_{IN}	—	10	—	pF	Note 3
Input Current	I_{LEAK}	—	—	**±1**	µA	—
Serial Clock Input, CLK						
Low Input Voltage	V_{IL}	—	—	**0.8**	V	3V ≤ V_{DD} ≤ 3.6V
High Input Voltage	V_{IH}	**2.1**	—	**5.5**	V	3V ≤ V_{DD} ≤ 3.6V
Input Capacitance	C_{IN}	—	10	—	pF	Note 3
Input Current	I_{LEAK}	—	—	**±1**	µA	—
Interrupt Output, /INT						
Low Output Voltage, Note 2	V_{OL}	—	—	**0.3**	V	I_{OL} = 3 mA
		—	—	**0.5**	V	I_{OL} = 6 mA
Interrupt Propagation Delay, Note 3, Note 5	t_{INT}	—	—	**[t_{CONV}]**	ms	From TEMPx < TLOWx or TEMPx > THIGHx or TEMPx > CRITx to /INT < VOL, R_{PULLUP} = 10 kΩ
Interrupt Reset Propagation Delay, Note 3, Note 8	t_{nINT}	—	—	**1**	µs	From read of STATUS or A.R.A. to /INT > V_{OH}, R_{PULLUP} = 10 kΩ
—	I_{LEAK}	—	—	**±1**	µA	—

Note 1: Specification for packaged product only.

2: Current into the /INT or DATA pins will result in self heating of the device. Sink current should be minimized for best accuracy.

3: Guaranteed by design over the operating temperature range. Not 100% production tested.

4: The device is not guaranteed to function outside its operating ratings. Final test on outgoing product is performed at TA = 25°C.

5: t_{INT} and t_{CRIT} are equal to t_{CONV}.

6: T_D is the temperature of the remote diode junction. Testing is performed using a single unit of one of the transistors listed in Table 8.

7: $t_{CONV} = t_{CONV(local)} + t_{CONV(remote)}$. Following the acquisition of either remote or local temperature data, the limit comparisons for that zone are performed and the device status updated. Status bits will be set and /INT driven active, if applicable.

8: The interrupt reset propagation delay is dominated by the capacitance on the bus.

9: Accuracy specification does not include quantization noise, which may be up to ±1/2 LSB.

10: Tested at 10-bit resolution.

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: V_{DD} = 3.3V; T_A = 25°C, unless noted. **Bold** values indicate –55°C ≤ T_A ≤ +125°C, 3.0V ≤ V_{DD} ≤ 3.6V, unless noted. (**Note 1**, **Note 2**, **Note 3**).

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Serial Interface Timing						
CLK (clock) Period	t_1	**2.5**	—	—	µs	—
Data In Setup Time to CLK High	t_2	**100**	—	—	ns	—
Data Out Stable after CLK Low	t_3	**300**	—	—	ns	—
Data Low Setup Time to CLK Low	t_4	**100**	—	—	ns	Start Condition
Data High Hold Time after CLK High	t_5	**100**	—	—	ns	Stop Condition
Bus Timeout	t_{TO}	**25**	30	**35**	ms	—

Note 1: Specification for packaged product only.

2: Current into the /INT or DATA pins will result in self heating of the device. Sink current should be minimized for best accuracy.

3: Guaranteed by design over the operating temperature range. Not 100% production tested.

4: The device is not guaranteed to function outside its operating ratings. Final test on outgoing product is performed at TA = 25°C.

5: t_{INT} and t_{CRIT} are equal to t_{CONV}.

6: T_D is the temperature of the remote diode junction. Testing is performed using a single unit of one of the transistors listed in Table 8.

7: $t_{CONV} = t_{CONV(local)} + t_{CONV(remote)}$. Following the acquisition of either remote or local temperature data, the limit comparisons for that zone are performed and the device status updated. Status bits will be set and /INT driven active, if applicable.

8: The interrupt reset propagation delay is dominated by the capacitance on the bus.

9: Accuracy specification does not include quantization noise, which may be up to ±1/2 LSB.

10: Tested at 10-bit resolution.

Timing Diagram

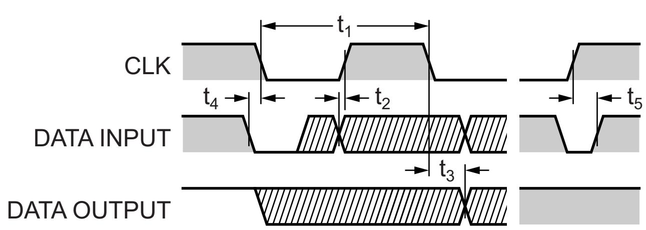


FIGURE 1-1: *Serial Interface Timing.*

TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Maximum Junction Temperature	T_J	—	—	+150	°C	Note 1
Storage Temperature Range	T_S	–65	—	+150	°C	—
Ambient Temperature Range	T_A	–55	—	+125	°C	—
Soldering	—	—	—	220 $^{+5}/_{-0}$	°C	Vapor Phase, 60s
	—	—	—	235 $^{+5}/_{-0}$	°C	Infrared, 15s
Package Thermal Resistances						
SOT23-6	θ_{JA}	—	230	—	°C/W	—

Note 1: The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e., T_A, T_J, θ_{JA}). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum +150°C rating. Sustained junction temperatures above +150°C can impact the device reliability.

2.0 TYPICAL PERFORMANCE CURVES

Note:	The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

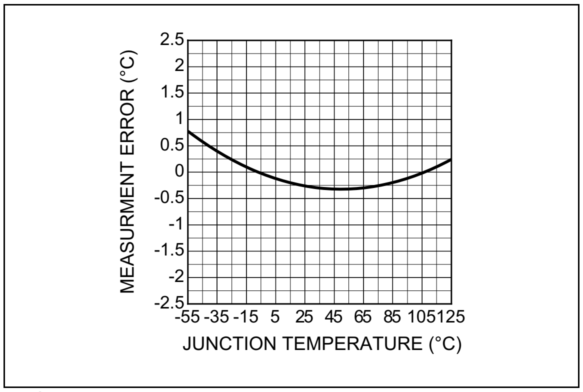


FIGURE 2-1: *Accuracy vs. Temperature, Internal Sensor.*

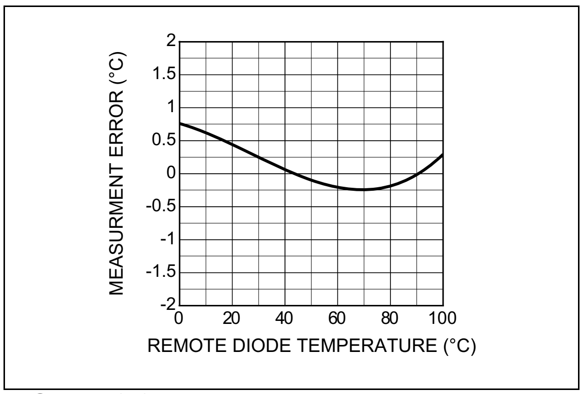


FIGURE 2-2: *Remote Temperature Measurement Error.*

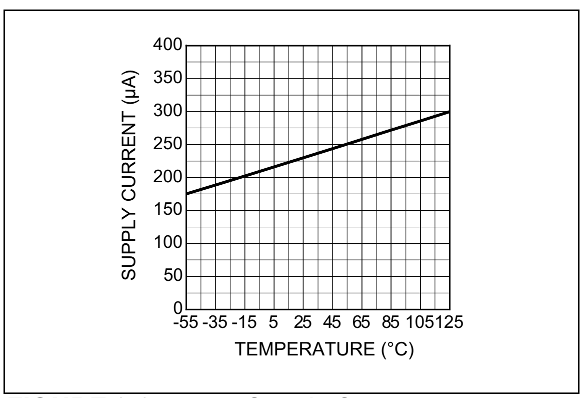


FIGURE 2-3: *Supply Current vs. Temperature for V_{DD} = 3.3V.*

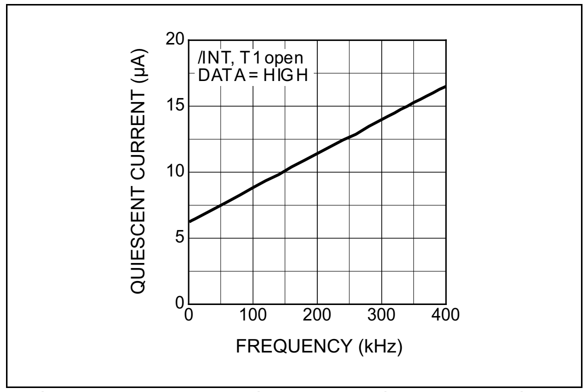


FIGURE 2-4: *Quiescent Current vs. Clock Frequency in Shutdown Mode.*

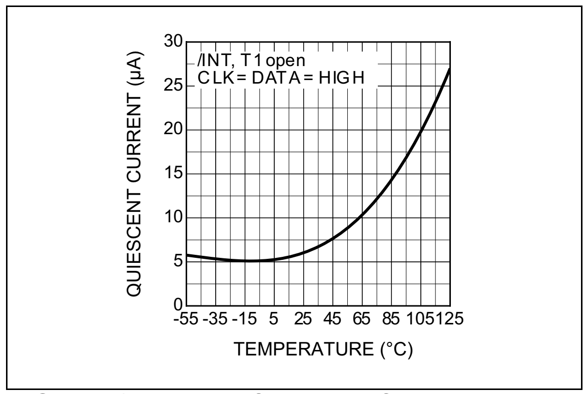


FIGURE 2-5: *Quiescent Current vs. Temperature in Shutdown Mode.*

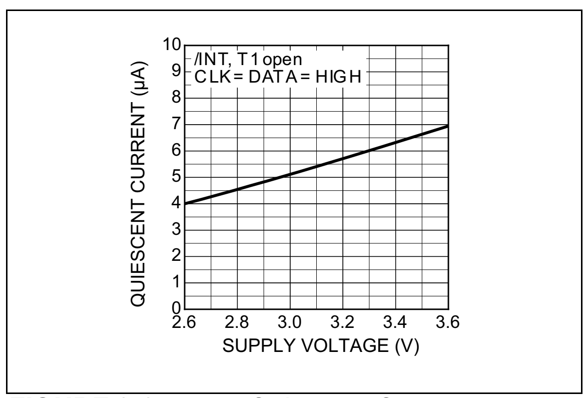


FIGURE 2-6: *Quiescent Current vs. Supply Voltage in Shutdown Mode.*

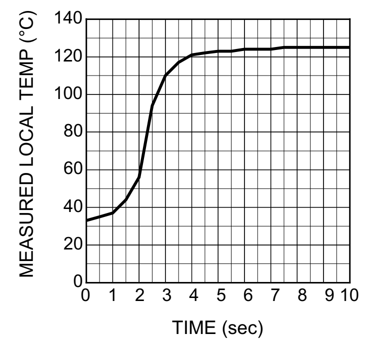


FIGURE 2-7: *Response to Immersion in +125°C Fluid Bath.*

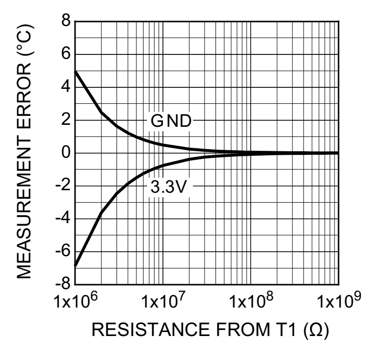


FIGURE 2-8: *Measurement Error vs. PCB Leakage to +3.3V/GND.*

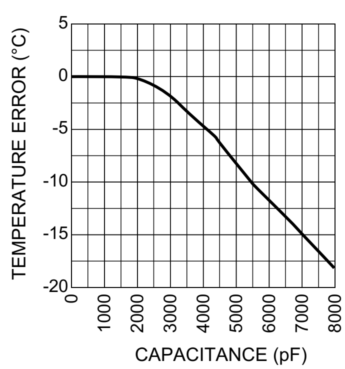


FIGURE 2-9: *Remote Temperature Error vs. Capacitance on T1.*

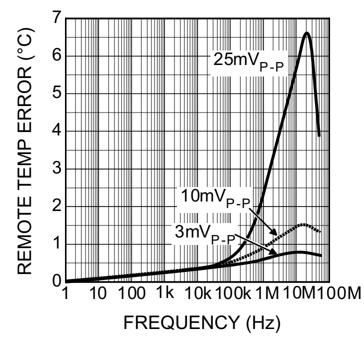


FIGURE 2-10: *Noise Injected into the Base of Remote Transistor.*

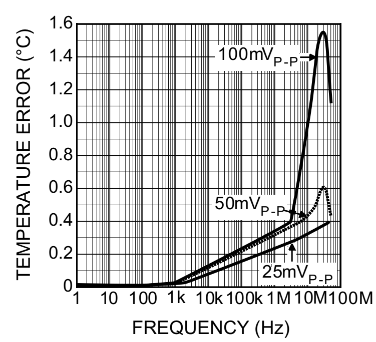


FIGURE 2-11: *Noise Injected into the Collector of Remote Transistor.*

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: MIC841 PIN FUNCTION TABLE

Pin Number	Symbol	Description
1	VDD	Power supply input.
2	GND	Ground.
3	T1	Analog input. Connection to remote diode junction.
4	CLK	Digital input. Serial bit clock input.
5	DATA	Digital input/output. Open-drain. Serial data input/output.
6	/INT	Digital output. Open-drain. Interrupt output.

4.0 FUNCTIONAL DESCRIPTION

4.1 Serial Port Operation

The MIC280 uses standard SMBus Write_Byte, Read_Byte, and Read_Word operations for communication with its host. The SMBus Write_Byte operation involves sending the device's client address (with the R/W bit low, to signal a write operation), followed by a command byte and the data byte. The SMBus Read_Byte operation is a composite write and read operation: the host first sends the device's client address followed by the command byte, as in a write operation. A new start bit must then be sent to the MIC280, followed by a repeat of the client address with the R/W bit (LSB) set to the high (read) state. The data to be read from the part may then be clocked out. A Read_Word is similar, but two successive data bytes are clocked out rather than one. These protocols are shown in Figure 4-1, Figure 4-2, and Figure 4-3.

The Command byte is eight bits (one byte) wide. This byte carries the address of the MIC280 register to be operated upon. The command byte values corresponding to the various MIC280 registers are shown in Table 4-2. Other command byte values are reserved, and should not be used.

4.2 Client Address

The MIC280 will only respond to its own unique client address. A match between the MIC280's address and the address specified in the serial bit stream must be made to initiate communication. The MIC280's client address is fixed at the time of manufacture. Eight different client addresses are available as determined by the part number. See Table 4-1 and the Product Identification System section.

TABLE 4-1: MIC280 CLIENT ADDRESSES

Part Number	Client Address
MIC280-0YM6	$100\ 1000_b = 48_h$
MIC280-1YM6	$100\ 1001_b = 49_h$
MIC280-2YM6	$100\ 1010_b = 4A_h$
MIC280-3YM6	$100\ 1011_b = 4B_h$
MIC280-4YM6	$100\ 1100_b = 4C_h$
MIC280-5YM6	$100\ 1101_b = 4D_h$
MIC280-6YM6	$100\ 1110_b = 4E_h$
MIC280-7YM6	$100\ 1111_b = 4F_h$

TABLE 4-2: MIC280 REGISTER ADDRESSES

Target Register		Command Byte Value		Power-On Default
Label	Description	Read	Write	
TEMP0	Local temperature result	00_h	N/A	00_h (0°C)
TEMP1h	Remote temperature result, high byte	01_h	N/A	00_h (0°C)
STATUS	Status	02_h	N/A	00_h
CONFIG	Configuration	03_h	03_h	80_h
IMASK	Interrupt mask register	04_h	04_h	07_h
THIGH0	Local temperature high limit	05_h	05_h	$3C_h$ (60°C)
TLOW0	Local temperature low limit	06_h	06_h	00_h (0°C)
THIGH1h	Remote temperature high limit, high byte	07_h	07_h	50_h (80°C)
TLOW1h	Remote temperature low limit, high byte	08_h	08_h	00_h (0°C)
LOCK	Security register	09_h	09_h	00_h
TEMP1l	Remote temperature result, low byte	10_h	N/A	00_h
THIGH1l	Remote temperature high limit, low byte	13_h	13_h	00_h
TLOW1l	Remote temperature low limit, low byte	14_h	14_h	00_h
CRIT1	Remote overtemperature limit	19_h	19_h	64_h (100°C)
CRIT0	Local overtemperature limit	20_h	20_h	46_h (70°C)
MFG_ID	Manufacturer identification	FE_h	N/A	$2A_h$
DEV_ID	Device and revision identification	FF_h	N/A	$0x_h$ (Note 1)

Note 1: The lower nibble contains the die revision level, (e.g., Rev. 0 = 00h).

4.3 Alert Response Address

In addition to the Read_Byte, Write_Byte, and Read_Word protocols, the MIC280 adheres to the SMBus protocol for response to the Alert Response Address (A.R.A.). The MIC280 expects to be interrogated using the ARA when it has asserted its /INT output.

4.4 Temperature Data Format

The least-significant bit of each temperature register (high bytes) represents one degree Centigrade. The values are in a two's complement format, wherein the most significant bit (D7) represents the sign: zero for positive temperatures and one for negative temperatures. Table 4-3 shows examples of the data used by the MIC280 for temperatures.

TABLE 4-3: TEMPERATURE FORMAT, HIGH BYTES

Temperature	Binary	Hex
+127°C	0111 1111	7F
+125°C	0111 1101	7D
+25°C	0001 1001	19
+1°C	0000 0001	01
0°C	0000 0000	00
–1°C	1111 1111	FF
–25°C	1110 0111	E7
–125°C	1000 0011	83
–128°C	1000 0000	80

Extended temperature resolution is provided for the external zone. The high and low temperature limits and the measured temperature for zone one are reported as 12-bit values stored in a pair of 8-bit registers. The measured temperature, for example, is reported in registers TEMP1h, the high-order byte, and TEMP1l, the low-order byte. The values in the low-order bytes are left-justified four-bit binary values representing one-sixteenth degree increments.

The A-D converter resolution for zone one is selectable from nine to twelve bits via the configuration register. Low-order bits beyond the resolution selected will be reported as zeroes. Examples of this format are shown in Table 4-5.

4.5 Fault Queue

A set of fault queues (programmable digital filters) are provided in the MIC280 to prevent false tripping due to thermal or electrical noise. Two bits, CONFIG[5:4], set the depth of the fault queues. The fault queue setting then determines the number of consecutive temperature events (TEMPx > THIGHx or TEMPx < TLOWx) which must occur in order for the condition to be considered valid. As an example, assume CONFIG[5:4] is programmed with 10b. The measured temperature for a given zone would have to exceed THIGHx for four consecutive A/D conversions before /INT would be asserted or the status bit set.

Like any filter, the fault queue function also has the effect of delaying the detection of temperature events. In this example, it would take 4 × tCONV to detect a temperature event. The fault queue depth versus CONFIG[5:4] of the configuration register is shown in Table 4-4. Note that there is no fault queue for overtemperature events (CRIT0 and CRIT1) or diode faults. The fault queue applies only to high-temperature and low-temperature events as determined by the THIGHx and TLOWx registers. Any write to CONFIG will result in the fault queues being purged and reset. Writes to any of the limit registers, TLOWx or THIGHx, will result in the fault queue for the corresponding zone being purged and reset.

TABLE 4-4: FAULT QUEUE DEPTH SETTINGS

CONFIG[5:4]	Fault Queue Depth
00	1 (default)
01	2
10	4
11	6

TABLE 4-5: DIGITAL TEMPERATURE FORMAT, LOW BYTES

Extended Temperature Low Byte	Resolution			
	9 Bits	10 Bits	11 Bits	12 Bits
	Binary – Hex	Binary – Hex	Binary – Hex	Binary – Hex
0.0000	0000 0000 – 00	0000 0000 – 00	0000 0000 – 00	0000 0000 – 00
0.0625	0000 0000 – 00	0000 0000 – 00	0000 0000 – 00	0001 0000 – 10
0.1250	0000 0000 – 00	0000 0000 – 00	0010 0000 – 20	0010 0000 – 20
0.2500	0000 0000 – 00	0100 0000 – 40	0100 0000 – 40	0100 0000 – 40
0.5625	1000 0000 – 80	1000 0000 – 80	1000 0000 – 80	1001 0000 – 90
0.9375	1000 0000 – 80	1100 0000 – C0	1110 0000 – E0	1111 0000 – F0

4.6 Interrupt Generation

There are eight different conditions that will cause the MIC280 to set one of the bits in STATUS and assert its /INT output, if so enabled. These conditions are listed in Table 4-6. Unlike previous generations of thermal supervisor ICs, there are no interdependencies between any of these conditions. That is, if CONDITION is true, the MIC280 will respond accordingly, regardless of any previous or currently pending events.

Normally when a temperature event occurs, the corresponding status bit will be set in STATUS, the corresponding interrupt mask bit will be cleared, and /INT will be asserted. Clearing the interrupt mask bit(s) prohibits continuous interrupt generation while the device is being serviced. It is possible to prevent events from clearing interrupt mask bits by setting bits in the lock register. See Table 4-7 for Lockbit functionality. A temperature event will only set bits in the status register if it is specifically enabled by the corresponding bit in the interrupt mask register. An interrupt signal will only be generated on /INT if interrupts are also globally enabled (IE = 1 in CONFIG).

The MIC280 expects to be interrogated using the Alert Response Address once it has asserted its interrupt output. Following an interrupt, a successful response to the A.R.A. or a read operation on STATUS will cause /INT to be de-asserted. STATUS will also be cleared by the read operation. Reading STATUS following an interrupt is an acceptable substitute for using the A.R.A. if the host system does not implement the A.R.A protocol. Figure 4-4 and Figure 4-5 illustrate these two methods of responding to MIC280 interrupts.

Because temperature-to-digital conversions continue while /INT is asserted, the measured temperature could change between the MIC280's assertion of /INT and the host's response. It is good practice for the interrupt service routine to read the value in TEMPx to verify that the overtemperature or undertemperature condition still exists. In addition, more than one temperature event may have occurred simultaneously or in rapid succession between the assertion of /INT and servicing of the MIC280 by the host. The interrupt service routine should allow for this eventuality. At the end of the interrupt service routine, the interrupt enable bits should be reset to permit future interrupts.

4.7 Reading the Result Registers

All MIC280 registers are eight bits wide and may be accessed using the standard Read_Byte protocol. The temperature result for the local zone, zone 0, is a single 8-bit value in register TEMP0. A single Read_Byte operation by the host is sufficient for retrieving this value. The temperature result for the remote zone is a twelve-bit value split across two eight-bit registers, TEMP1h and TEMP1l. A series of two Read_Byte operations are needed to obtain the entire twelve-bit temperature result for zone 1. It is possible under certain conditions that the temperature result for zone 1 could be updated between the time TEMP1l or TEMP1h is read and the companion register is read. In order to ensure coherency, TEMP1h supports the use of the Read_Word protocol for accessing both TEMP1h and TEMP1l with a single operation. This ensures that the values in both result registers are from the same ADC cycle. This is illustrated in Figure 4-3. Read_Word operations are only supported for TEMP1h: TEMP1l, i.e., only for command byte values of 01h.

4.8 Polling

The MIC280 may either be polled by the host or request the host's attention via the /INT pin. In the case of polled operation, the host periodically reads the contents of STATUS to check the state of the status bits. The act of reading STATUS clears it. If more than one event that sets a given status bit occurs before the host polls STATUS, only the fact that at least one such event has occurred will be apparent to the host. For polled systems, the global interrupt enable bit should be clear (IE = 0). This will disable interrupts from the MIC280 (prevents the /INT pin from sinking current). For interrupt-driven systems, IE must be set to enable the /INT output.

4.9 Shutdown Mode

Putting the device into shutdown mode by setting the shutdown bit in the configuration register will unconditionally deassert /INT, clear STATUS, and purge the fault queues. Therefore, this should not be done before completing the appropriate interrupt service routine(s). No other registers will be affected by entering shutdown mode. The last temperature readings will persist in the TEMPx registers.

The MIC280 can be prevented from entering shutdown mode using the shutdown lockout bit in the lock register. If L3 in LOCK is set while the MIC280 is in shutdown mode, it will immediately exit shutdown mode and resume normal operation. It will not be possible to subsequently re-enter shutdown mode. If the reset bit is set while the MIC280 is shut down, normal operation resumes from the reset state.

4.10 Warm Resets

The MIC280 can be reset to its power-on default state during operation by setting the RST bit in the configuration register. When this bit is set, /INT will be deasserted, the fault queues will be purged, the limit registers will be restored to their normal power-on default values, and any A/D conversion in progress will be halted and the results discarded. This includes resetting bits L3 through L0 in the security register, LOCK. The state of the MIC280 following this operation is indistinguishable from a power-on reset. If the reset bit is set while the MIC280 is shut down, the shutdown bit is cleared and normal operation resumes from the reset state.

If bit 4 of LOCK, the Warm Reset Lockout Bit, is set, warm resets cannot be initiated, and writes to the RST bit will be completely ignored. Setting L4 while the MIC280 is shut down will result in the device exiting shutdown mode and resuming normal operation, just as if the shutdown bit had been cleared.

TABLE 4-6: MIC280 TEMPERATURE EVENTS

Event	Condition	MIC280 Response (Note 1)
Data ready	A/D conversions complete for both zones; result registers updated; state of /INT updated	Set S7, clear IM7, assert /INT
Overtemperature, remote	([TEMP1h:TEMP1l]) >CRIT1	Set S1, assert /INT
Overtemperature, local	TEMP0 >CRIT0	Set S0, assert /INT
High temperature, remote	([TEMP1h:TEMP1l]) >[THIGH1h:THIGH1l](Note 2)	Set S4, clear IM4, assert /INT
High temperature, local	TEMP0 >THIGH0(Note 2)	Set S6, clear IM6, assert /INT
Low temperature, remote	([TEMP1h:TEMP1l]) <[TLOW1h:TLOW1l](Note 2)	Set S3, clear IM3, assert /INT
Low temperature, local	TEMP0 <TLOW0(Note 2)	Set S5, clear IM5, assert /INT
Diode fault	T1 open or T1 shorted to VDD or GND	Set S2, clear IM2, assert /INT

Note 1: Assumes interrupts enabled.

2: CONDITION must be true for Fault_Queue conversions to be recognized.

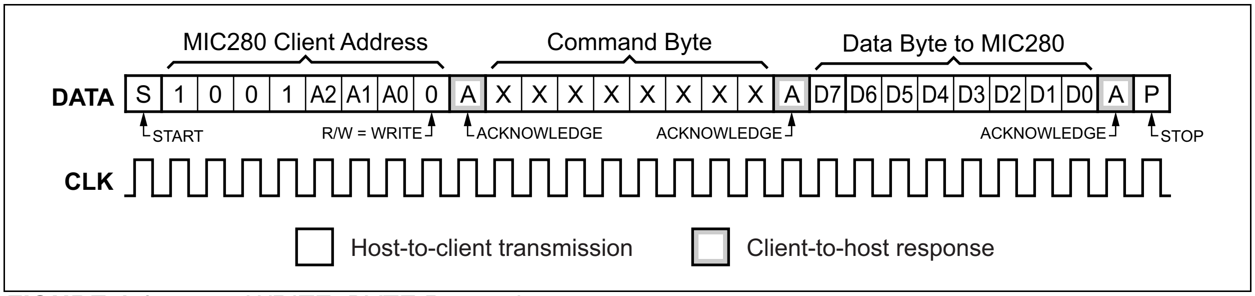


FIGURE 4-1: *WRITE_BYTE Protocol.*

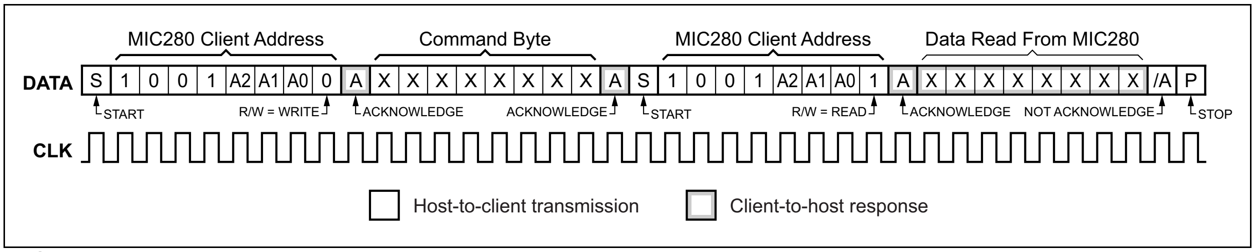


FIGURE 4-2: *READ_BYTE Protocol.*

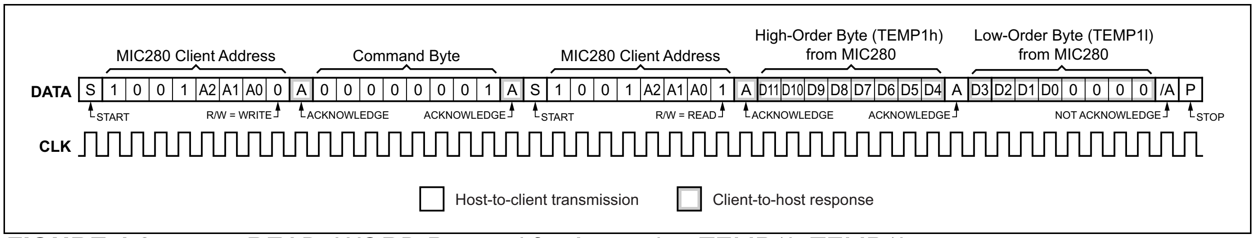


FIGURE 4-3: *READ_WORD Protocol for Accessing TEMP1h:TEMP1l.*

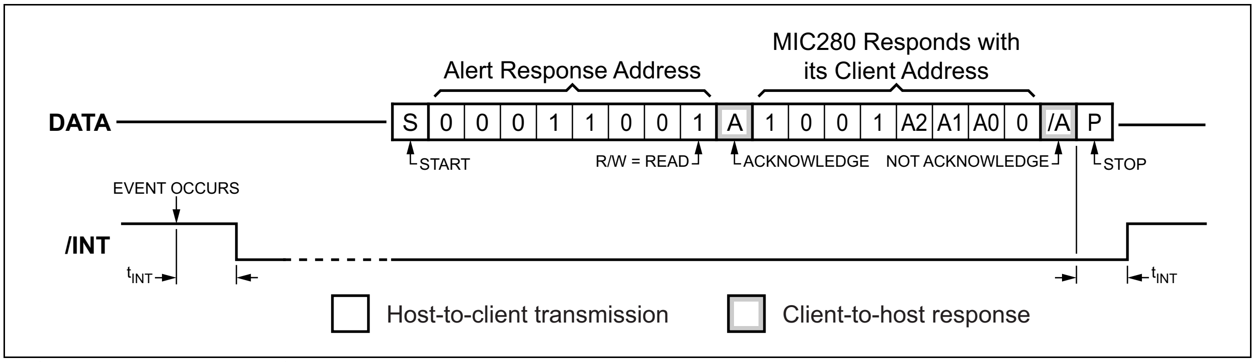


FIGURE 4-4: MIC280 Alert Response Address Protocol.

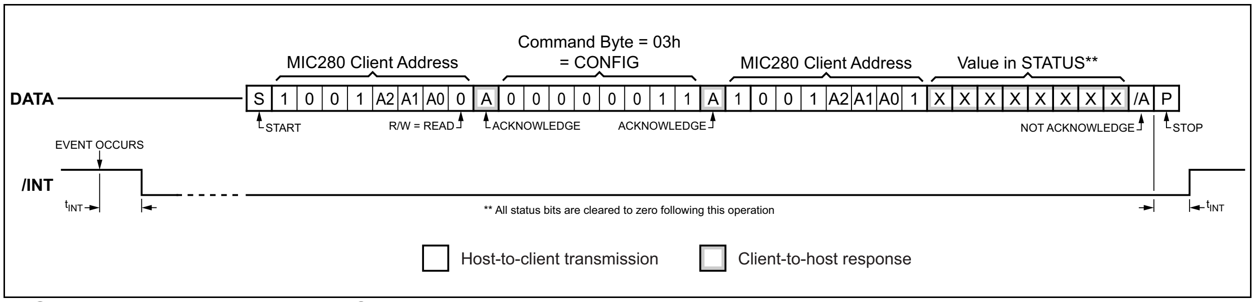


FIGURE 4-5: Reading Status in Response to an Interrupt.

4.11 Configuration Locking

The security register, LOCK, provides the ability to disable configuration changes as they apply to the MIC280's most critical functions: shutdown mode, and reporting diode faults and overtemperature events. LOCK provides a way to prevent malicious or accidental changes to the MIC280 registers that might prevent a system from responding properly to critical events. Once L0, L1, or L2 has been set, the global interrupt enable bit, IE, will be set and fixed. It cannot subsequently be cleared. Its state will be reflected in the configuration register. The bits in LOCK can only be set once. That is, once a bit is set, it cannot be reset until the MIC280 is power-cycled or a warm reset is performed by setting RST in the configuration register. The warm reset function can be disabled by setting L4 in LOCK. If L4 is set, locked settings cannot be changed during operation and warm resets cannot be performed; only a power-cycle will reset the locked state(s).

If L0 is set, the values of IM0 and CRIT0 become fixed and unchangeable. That is, writes to CRIT0 and the corresponding interrupt enable bit are locked out.

A local overtemperature event will generate an interrupt regardless of the setting of IE or its interrupt mask bit.

If L1 is set, the values of IM1 and CRIT1 become fixed and unchangeable. A remote over-temperature event will generate an interrupt regardless of the setting of IE or its interrupt mask bit. Similarly, setting L2 will fix the state of IM2, allowing the system to permanently enable or disable diode fault interrupts. A diode fault will generate an interrupt regardless of the setting of IE or its interrupt mask bit.

L3 can be used to lock out shutdown mode. If L3 is set, the MIC280 will not shut down under any circumstances. Attempts to set the SHDN bit will be ignored and all chip functions will remain operational. If L3 is set while the MIC280 is in shutdown mode, it will immediately exit shutdown mode and resume normal operation. It will not be possible to subsequently re-enter shutdown mode.

Setting L4 disables the RST bit in the configuration register, preventing the host from initiating a warm reset. Writes to RST will be completely ignored if L4 is set.

TABLE 4-7: LOCK BIT FUNCTIONALITY

Lock Bit	Function Locked	Response When Set
L0	Local overtemperature detection	IM0 fixed at 1, writes to CRIT0 locked-out; IE permanently set
L1	Remote overtemperature detection	IM1 fixed at 1; writes to CRIT1 locked-out; IE permanently set
L2	Diode fault interrupts locked on or off	IM2 fixed at current state; IE permanently set if IM2=1
L3	Shutdown Mode	SHDN fixed at 0; exit shutdown if SHDN=1 when L3 is set
L4	Warm Resets	RST bit disabled; cannot initiate warm resets

5.0 DETAILED REGISTER DESCRIPTIONS

5.1 Local Temperature Result Register (TEMP0) 8-Bits, Read-Only

TABLE 5-1: TEMPERATURE DATA FROM ADC

Local Temperature Result Register							
D[7] read-only	D[6] read-only	D[5] read-only	D[4] read-only	D[3] read-only	D[2] read-only	D[1] read-only	D[0] read-only
Bit		**Function**				**Operation**	
D[7:0]		Measured temperature data for the local zone.				Read-only	

Power-up default value: 0000 0000_b = 00_h = (0°C)

Note that TEMP0 will contain measured temperature data after the completion of one conversion.

Read command byte: 0000 0000_b = 00_h

Each LSB represents one degree centigrade. The values are in a twos complement binary format such that 0°C is reported as 0000 0000_b. See the Temperature Data Format section for more details.

5.2 Remote Temperature Result High Byte Register (TEMP1h) 8-Bits, Read-Only

TABLE 5-2: TEMPERATURE DATA FROM ADC

Remote Temperature Result High Byte Register							
D[7] read-only	D[6] read-only	D[5] read-only	D[4] read-only	D[3] read-only	D[2] read-only	D[1] read-only	D[0] read-only
Bit		**Function**				**Operation**	
D[7:0]		Measured temperature data for the remote zone, most significant byte.				Read-only	

Power-up default value: 0000 0000_b = 00_h = (0°C)

Note that TEMP0 will contain measured temperature data after the completion of one conversion.

Read command byte: 0000 0001_b = 01_h

Each LSB represents one degree centigrade. The values are in a twos complement binary format such that 0°C is reported as 0000 0000_b. See the Temperature Data Format section for more details.

TEMP1h can be read using either a Read_Byte operation or a Read_Word operation. Using Read_Byte will yield the 8-bit value in TEMP1h. The complete remote temperature result in both TEMP1h and TEMP1l may be obtained by performing a Read_Word operation on TEMP1h. The MIC280 will respond to a Read_Word with a command byte of 01h (TEMP1h) by returning the value in TEMP1h followed by the value in TEMP1l. This guarantees that the data in both registers is from the same temperature-to-digital conversion cycle. The Read_Word operation is diagrammed in Figure 4-3. This is the only MIC280 register that supports Read_Word.

5.3 Status Register (STATUS) 8-Bits, Read-Only

TABLE 5-3: STATUS REGISTER INFORMATION

Status Register							
D[7] read-only	D[6] read-only	D[5] read-only	D[4] read-only	D[3] read-only	D[2] read-only	D[1] read-only	D[0] read-only
S7	S6	S5	S4	S3	S2	S1	S0

Bit	Function	Operation (Note 1)
S7	Data ready	1 = data available, 0 = ADC busy
S6	Local high temperature event	1 = event occurred, 0 = none
S5	Local low temperature event	1 = event occurred, 0 = none
S4	Remote high temperature event	1 = event occurred, 0 = none
S3	Remote low temperature event	1 = event occurred, 0 = none
S2	Diode fault	1 = fault, 0 = none
S1	Remote overtemperature event	1 = event occurred, 0 = none
S0	Local overtemperature event	1 = event occurred, 0 = none

Note 1: All status bits are cleared after any read operation is performed on STATUS.

Power-up default value: $0000\ 0000_b = 00_h$ = (no events pending)

Read command byte: $0000\ 0010_b = 02_h$

The power-up default value is 00h. Following the first conversion, however, any of the status bits may be set depending on the measured temperature results or the existence of a diode fault.

5.4 Configuration Register (CONFIG) 8-Bits, Read/Write

TABLE 5-4: CONFIGURATION REGISTER INFORMATION

Configuration Register							
D[7] read/write	D[6] read/write	D[5] reserved	D[4] reserved	D[3] reserved	D[2] reserved	D[1] reserved	D[0] reserved
Interrupt Enable (IE)	Shutdown (SHDN)	Fault Queue (FQ[1:0])		Resolution (RES[1:0])		Reserved	Reset (RST)

Bit	Function	Operation
IE	Interrupt enable	1 = interrupts enabled, 0 = disabled
SHDN	Selects operating mode: normal/shutdown	1 = shutdown, 0 = normal
FQ[1:0]	Depth of fault queue	[00] = 1, [01] = 2, [10] = 4, [11] = 6
RES[1:0]	A/D converter resolution for external zone; affects conversion rate	[00] = 9-bits, [01] = 10-bits, [10] = 11-bits, [11] = 12-bits
D[1]	Reserved	Always write as zero
RST	Resets all MIC280 functions and restores the power-up default state	Write only; 1 = reset, 0 = normal Operation; disabled by setting L4

Any write to CONFIG will result in the fault queues being purged and reset and any A/D conversion in progress being aborted and the result discarded. The A/D will begin a new conversion sequence once the write operation is complete.

Power-up default value: 1000 0000_b = 80_h (not in shutdown mode; interrupts enabled; fault queue depth = 1; resolution = 9-bits)

Read/write command byte: 0000 0011_b = 03_h

5.5 Interrupt Mask Register (IMASK) 8-Bits, Read/Write

TABLE 5-5: INTERRUPT MASK REGISTER INFORMATION

Interrupt Mask Register							
D[7] read/write	D[6] read/write	D[5] reserved	D[4] reserved	D[3] reserved	D[2] reserved	D[1] reserved	D[0] reserved
IM7	IM6	IM5	IM4	IM3	IM2	IM1	IM0

Bit	Function	Operation
IM7	Data-ready event mask	1 = enabled, 0 = disabled
IM6	Local high temperature event mask	1 = enabled, 0 = disabled
IM5	Local low temperature event mask	1 = enabled, 0 = disabled
IM4	Remote high temperature event mask	1 = enabled, 0 = disabled
IM3	Remote low temperature event mask	1 = enabled, 0 = disabled
IM2	Diode fault mask	1 = enabled, 0 = disabled
IM1	Remote overtemperature event mask	1 = enabled, 0 = disabled
IM0	Local overtemperature event mask	1 = enabled, 0 = disabled

Power-up default value: 0000 0111_b = 07_h (overtemperature and diode faults enabled)

Read/write command byte: 0000 0100_b = 04_h

5.6 Local Temperature High Limit Register (THIGH0) 8-Bits, Read/Write

TABLE 5-6: LOCAL TEMPERATURE HIGH LIMIT REGISTER INFORMATION

Local Temperature High Limit Register							
D[7] read/write	D[6] read/write	D[5] read/write	D[4] read/write	D[3] read/write	D[2] read/write	D[1] read/write	D[0] read/write
High temperature limit for local zone.							

Bit	Function	Operation
D[7:0]	High temperature limit for the local zone.	Read/write

Power-up default value: 0011 1100_b = $3C_h$ (60°C)

Read/write command byte: 0000 0101_b = 05_h

Each LSB represents one degree centigrade. The values are in a two's complement binary format such that 0°C is reported as 0000 0000_b. See the Temperature Data Format section for more details.

Any writes to a temperature limit register will result in the corresponding fault queue being purged and reset.

5.7 Local Temperature Low Limit Register (TLOW0) 8-Bits, Read/Write

TABLE 5-7: LOCAL TEMPERATURE LOW LIMIT REGISTER INFORMATION

Local Temperature Low Limit Register							
D[7] read/write	D[6] read/write	D[5] read/write	D[4] read/write	D[3] read/write	D[2] read/write	D[1] read/write	D[0] read/write
Low temperature limit for the local zone.							
Bit		**Function**				**Operation**	
D[7:0]		Low temperature limit for the local zone.				Read/Write	

Power-up default value: 0000 0000_b = 00_h (0°C)

Read/write command byte: 0000 0110_b = 06_h

Each LSB represents one degree centigrade. The values are in a two's complement binary format such that 0°C is reported as 0000 0000_b. See the Temperature Data Format section for more details.

Any writes to a temperature limit register will result in the corresponding fault queue being purged and reset.

5.8 Remote Temperature High Limit High-Byte Register (THIGH1h) 8-Bits, Read/Write

TABLE 5-8: REMOTE TEMPERATURE HIGH LIMIT HIGH-BYTE REGISTER INFORMATION

Remote Temperature High Limit High-Byte Register							
D[7] read/write	D[6] read/write	D[5] read/write	D[4] read/write	D[3] read/write	D[2] read/write	D[1] read/write	D[0] read/write
High temperature limit for remote zone, most significant byte.							
Bit		**Function**				**Operation**	
D[7:0]		High temperature limit for remote zone, most significant byte.				Read/Write	

Power-up default value: 0101 0000_b = 50_h (80°C)

Read/write command byte: 0000 0111_b = 07_h

Each LSB represents one degree centigrade. The values are in a two's complement binary format such that 0°C is reported as 0000 0000_b. See the Temperature Data Format section for more details.

Any writes to a temperature limit register will result in the corresponding fault queue being purged and reset.

5.9 Remote Temperature Low Limit High-Byte Register (TLOW1h) 8-Bits, Read/Write

TABLE 5-9: REMOTE TEMPERATURE LOW LIMIT HIGH-BYTE REGISTER INFORMATION

Remote Temperature Low Limit High-Byte Register							
D[7] read/write	D[6] read/write	D[5] read/write	D[4] read/write	D[3] read/write	D[2] read/write	D[1] read/write	D[0] read/write
Low temperature limit for remote zone, most significant byte.							
Bit		**Function**				**Operation**	
D[7:0]		Low temperature limit for remote zone, most significant byte.				Read/Write	

Power-up default value: 0000 0000_b = 00_h (0°C)

Read/write command byte: 0000 1000_b = 08_h

Each LSB represents one degree centigrade. The values are in a two's complement binary format such that 0°C is reported as 0000 0000_b. See the Temperature Data Format section for more details.

Any writes to a temperature limit register will result in the corresponding fault queue being purged and reset.

5.10 Security Register (LOCK) 8-Bits, Write Once

TABLE 5-10: SECURITY REGISTER INFORMATION

Security Register							
D[7] reserved	D[6] reserved	D[5] reserved	D[4] read/write-once	D[3] read/write-once	D[2] read/write-once	D[1] read/write-once	D[0] read/write-once
Reserved			L4	L3	L2	L1	L0

Bit	Function	Operation
D[7:5]	Reserved	Always write as zero
L4	Warm-reset lockout bit	1 = RST bit disabled; 0 = unlocked
L3	Shutdown mode lockout bit	1 = shutdown disabled; 0 = unlocked
L2	Diode fault event lock bit	1 = locked; 0 = unlocked
L1	Remote overtemperature event lock bit	1 = locked; 0 = unlocked
L0	Local overtemperature event lock bit	1 = locked; 0 = unlocked

Power-up default value: $0000\ 0000_b = 00_h$ (all event unlocked)

Write command byte: $0000\ 1001_b = 09_h$

5.11 Remote Temperature Result Low-Byte Register (TLOW1I) 8-Bits, Read Only

TABLE 5-11: REMOTE TEMPERATURE RESULT LOW-BYTE REGISTER INFORMATION

Remote Temperature Result Low-Byte Register							
D[7] read-only	D[6] read-only	D[5] read-only	D[4] read-only	D[3] reserved	D[2] reserved	D[1] reserved	D[0] reserved
Temperature data from ADC, least significant bits. Reserved always reads zero.							

Bit	Function	Operation
D[7:4]	Measured temperature data for the remote zone, least significant bits.	Read only
D[3:0]	Reserved	Always reads as zero

Power-up default value: $0000\ 0000_b = 00_h$ (0°C). TEMP1I will contain measured temperature data after the completion of one conversion.

Read command byte: $0001\ 0000_b = 10_h$

Each LSB represents one-sixteenth degree centigrade. The values are in a binary format such that 1/16th°C (0.0625°C) is reported as $0001\ 0000_b$. See the Temperature Data Format section for more details.

TEMP1I can be accessed using a Read_Byte operation. However, the complete remote temperature result in both TEMP1h and TEMP1I may be obtained by performing a Read_Word operation on TEMP1h. The MIC280 will respond to a Read_Word with a command byte of 01h (TEMP1h) by returning the value in TEMP1h followed by the value in TEMP1I. This guarantees that the data in both registers is from the same temperature-to-digital conversion cycle. The Read_Word operation is diagrammed in Figure 4-3. TEMP1h is the only MIC280 register that supports Read_Word.

5.12 Remote Temperature High Limit Low-Byte Register (THIGH1I) 8-Bits, Read/Write

TABLE 5-12: REMOTE TEMPERATURE HIGH LIMIT LOW-BYTE REGISTER INFORMATION

Remote Temperature High Limit Low-Byte Register							
D[7] read/write	D[6] read/write	D[5] read/write	D[4] read/write	D[3] reserved	D[2] reserved	D[1] reserved	D[0] reserved
High temperature limit for remote zone, least significant bits. Reserved always reads zero.							

TABLE 5-12: REMOTE TEMPERATURE HIGH LIMIT LOW-BYTE REGISTER INFORMATION

Remote Temperature High Limit Low-Byte Register		
Bit	**Function**	**Operation**
D[7:4]	High temperature limit for the remote zone, least significant bits.	Read/Write
D[3:0]	Reserved	Always reads as zero

Power-up default value: 0000 0000_b = 00_h (0°C)

Read/write command byte: 0001 0011_b = 13_h

Each LSB represents one-sixteenth degree centigrade. The values are in a binary format such that 1/16th°C (0.0625°C) is reported as 0001 0000_b. See the Temperature Data Format section for more details.

Any writes to a temperature limit register will result in the corresponding fault queue being purged and reset.

5.13 Remote Temperature Low Limit Low-Byte Register (TLOW1l) 8-Bits, Read/Write

TABLE 5-13: REMOTE TEMPERATURE LOW LIMIT LOW-BYTE REGISTER INFORMATION

Remote Temperature Low Limit Low-Byte Register							
D[7] read/write	D[6] read/write	D[5] read/write	D[4] read/write	D[3] reserved	D[2] reserved	D[1] reserved	D[0] reserved
Low temperature limit for remote zone, least significant bits. Reserved always reads zero.							

Bit	**Function**	**Operation**
D[7:4]	Low temperature limit for the remote zone, least significant bits.	Read/Write
D[3:0]	Reserved	Always reads as zero

Power-up default value: 0000 0000_b = 00_h (0°C)

Read/write command byte: 0001 0100_b = 14_h

Each LSB represents one-sixteenth degree centigrade. The values are in a binary format such that 1/16th°C (0.0625°C) is reported as 0001 0000_b. See the Temperature Data Format section for more details.

Any writes to a temperature limit register will result in the corresponding fault queue being purged and reset.

5.14 Remote Overtemperature Limit Register (CRIT1) 8-Bits, Read/Write

TABLE 5-14: REMOTE OVERTEMPERATURE LIMIT REGISTER INFORMATION

Remote Overtemperature Limit Register							
D[7] read/write	D[6] read/write	D[5] read/write	D[4] read/write	D[3] read/write	D[2] read/write	D[1] read/write	D[0] read/write
Overtemperature limit for remote zone.							

Bit	**Function**	**Operation**
D[7:0]	Overtemperature limit for the remote zone.	Read/Write

Power-up default value: 0110 0100_b = 64_h (100°C)

Read/write command byte: 0001 1001_b = 19_h

Each LSB represents one degree centigrade. The values are in a two's complement binary format such that 0°C is reported as 0000 0000_b. See the Temperature Data Format section for more details.

Any writes to a temperature limit register will result in the corresponding fault queue being purged and reset.

5.15 Local Overtemperature Limit Register (CRIT0) 8-Bits, Read/Write

TABLE 5-15: LOCAL OVERTEMPERATURE LIMIT REGISTER INFORMATION

Local Overtemperature Limit Register							
D[7] read/write	D[6] read/write	D[5] read/write	D[4] read/write	D[3] read/write	D[2] read/write	D[1] read/write	D[0] read/write
Overtemperature limit for local zone.							
Bit		**Function**				**Operation**	
D[7:0]		Overtemperature limit for local zone.				Read/Write	

Power-up default value: 0100 0110_b = 46_h (70°C)

Read/write command byte: 0010 0000_b = 20_h

Each LSB represents one degree centigrade. The values are in a two's complement binary format such that 0°C is reported as 0000 0000_b. See the Temperature Data Format section for more details.

Any writes to a temperature limit register will result in the corresponding fault queue being purged and reset.

5.16 Manufacturer ID Register (MFG_ID) 8-Bits, Read Only

TABLE 5-16: MANUFACTURER ID REGISTER INFORMATION

Manufacturer ID Register							
D[7] read-only	D[6] read-only	D[5] read-only	D[4] read-only	D[3] read-only	D[2] read-only	D[1] read-only	D[0] read-only
0	0	1	0	1	0	1	0
Bit		**Function**				**Operation**	
D[7:0]		Identifies Microchip as the manufacturer of the device				Read only. Always returns $2A_h$	

Power-up default value: 0010 1010_b = $2A_h$

Read command byte: 1111 1110_b = FE_h

5.17 Die Revision Register (DIE_REV) 8-Bits, Read Only

TABLE 5-17: DIE REVISION REGISTER INFORMATION

Die Revision Register							
D[7] read-only	D[6] read-only	D[5] read-only	D[4] read-only	D[3] read-only	D[2] read-only	D[1] read-only	D[0] read-only
MIC280 die revision number							
Bit		**Function**				**Operation**	
D[7:0]		Identifies the device revision number				Read only	

Power-up default value: [device revision number]$_h$

Read command byte: 1111 1111_b = FF_h

6.0 APPLICATION INFORMATION

6.1 Remote Diode Section

Most small-signal PNP transistors with characteristics similar to the JEDEC 2N3906 will perform well as remote temperature sensors. Table 6-1 lists several examples of such parts that Microchip has tested for use with the MIC280. Other transistors equivalent to these should also work well.

TABLE 6-1: TRANSISTORS SUITABLE FOR USE AS REMOTE DIODES

Vendor	Part Number	Package
Fairchild Semiconductor	MMBT3906	SOT-23
On Semiconductor	MMBT3906L	SOT-23
Philips Semiconductor	PMBT3906	SOT-23
Samsung Semiconductor	KST3906-TF	SOT-23

6.2 Minimizing Errors

6.2.1 SELF-HEATING

One concern when using a part with the temperature accuracy and resolution of the MIC280 is to avoid errors induced by self-heating (V_{DD} × I_{DD}) + (V_{OL} × I_{OL}). In order to understand what level of error this might represent, and how to reduce that error, the dissipation in the MIC280 must be calculated and its effects reduced to a temperature offset. The worst-case operating condition for the MIC280 is when V_{DD} = 3.6V. The maximum power dissipated in the part is given in the following equations:

EQUATION 6-1:

$$P_D = [(I_{DD} \times V_{DD}) + (I_{OL(DATA)} \times V_{OL(DATA)}) + (I_{OL(/\mathrm{INT})} \times V_{OL(/\mathrm{INT})})]$$

EQUATION 6-2:

$$P_D = [(0.4mA \times 3.6V) + (6mA \times 0.5V) + (6mA \times 0.5V)] = 7.44mW$$

$R_{\theta(JA)}$ of the SOT23-6 package is 230°C/W. Theoretical Maximum ΔT_J due to self-heating is:

EQUATION 6-3:

$$7.44mW \times 230°C/\mathrm{W} = 1.7112°C$$

In most applications, the /INT output will be low for at most a few milliseconds before the host resets it back to the high state, making its duty cycle low enough that its contribution to self-heating of the MIC280 is negligible. Similarly, the DATA pin will in all likelihood have a duty cycle of substantially below 25% in the low state. These considerations, combined with more typical device and application parameters, give a better system-level view of device self-heating in interrupt-mode usage given in the following equations:

EQUATION 6-4:

$$(0.23mA\ I_{DD(TYP)} \times 3.3V) + (0.25 \times 1.5mA\ I_{OL(DATA)} \times 0.15V) + (0.01 \times 1.5mA\ I_{OL(/\mathrm{INT})} \times 0.15V) = 0.817mW$$

EQUATION 6-5:

$$\Delta T_J = (0.8175mW \times 230°C/\mathrm{W}) = 0.188°C$$

In any application, the best test is to verify performance against calculation in the final application environment. This is especially true when dealing with systems for which temperature data may be poorly defined or unobtainable except by empirical means.

6.2.2 SERIES RESISTANCE

The operation of the MIC280 depends upon sensing the V_{CB-E} of a diode-connected PNP transistor (diode) at two different current levels. For remote temperature measurements, this is done using an external diode connected between T1 and ground. Because this technique relies upon measuring the relatively small voltage difference resulting from two levels of current through the external diode, any resistance in series with the external diode will cause an error in the temperature reading from the MIC280. A good rule of thumb is that for each ohm in series with the external transistor, there will be a 0.8°C error in the MIC280’s temperature measurement. It is not difficult to keep the series resistance well below an ohm (typically <0.1Ω), so this will rarely be an issue.

6.3 Filter Capacitor Selection

It is usually desirable to employ a filter capacitor between the T1 and GND pins of the MIC280. The use of this capacitor is recommended in environments with a lot of high frequency noise (such as digital switching noise), or if long wires are used to connect to the remote diode. The maximum recommended total capacitance from the T1 pin to GND is 2200 pF. This typically suggests the use of a 1800 pF NP0 or C0G ceramic capacitor with a 10% tolerance. If the remote diode is to be at a distance of more than six-to-twelve inches from the MIC280, using twisted pair wiring or shielded microphone cable for the connections to the diode can significantly reduce noise pickup. If using a long run of shielded cable, remember to subtract the cable's conductor-to-shield capacitance from the 2200 pF maximum total capacitance.

6.4 Layout Considerations

The following guidelines should be kept in mind when designing and laying out circuits using the MIC280.

1. Place the MIC280 as close to the remote diode as possible, while taking care to avoid severe noise sources such as high frequency power transformers, CRTs, memory and data busses, and the like.
2. Because any conductance from the various voltages on the PC board and the T1 line can induce serious errors, it is good practice to guard the remote diode's emitter trace with a pair of ground traces. These ground traces should be returned to the MIC280's own ground pin. They should not be grounded at any other part of their run. However, it is highly desirable to use these guard traces to carry the diode's own ground return back to the ground pin of the MIC280, thereby providing a Kelvin connection for the base of the diode. See Figure 6-1.
3. When using the MIC280 to sense the temperature of a processor or other device which has an integral thermal diode, e.g., Intel's Pentium II, III, IV, AMD Athlon CPU, Xilinx Virtex FPGAs, connect the emitter and base of the remote sensor to the MIC280 using the guard traces and Kelvin return shown in Figure 6-1. The collector of the remote diode is typically inaccessible to the user on these devices. To allow for this, the MIC280 has superb rejection of noise appearing from collector to GND.
4. Due to the small currents involved in the measurement of the remote diode's ΔV_{BE}, it is important to adequately clean the PC board after soldering to prevent current leakage. This is most likely to show up as an issue in situations where water-soluble soldering fluxes are used.
5. In general, wider traces for the ground and T1 lines will help reduce susceptibility to radiated noise (wider traces are less inductive). Use trace widths and spacing of 10 mm wherever possible and provide a ground plane under the MIC280 and under the connections from the MIC280 to the remote diode. This will help guard against stray noise pickup.
6. Always place a good quality power supply bypass capacitor directly adjacent to, or underneath, the MIC280. This should be a 0.1 µF ceramic capacitor. Surface-mount parts provide the best bypassing because of their low inductance.
7. When the MIC280 is being powered from particularly noisy power supplies, or from supplies which may have sudden high-amplitude spikes appearing on them, it can be helpful to add additional power supply filtering. This should be implemented as a 100Ω resistor in series with the part's V_{DD} pin, and a 4.7 µF, 6.3V electrolytic capacitor from V_{DD} to GND. See Figure 6-2.

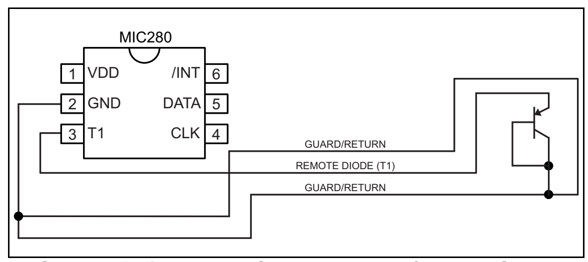


FIGURE 6-1: *Guard Traces/Kelvin Ground Returns.*

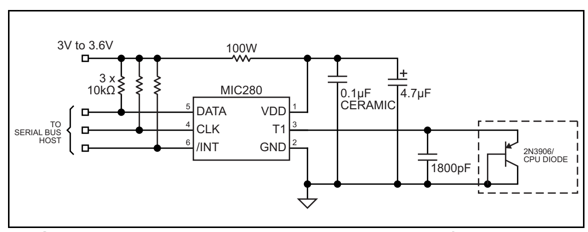
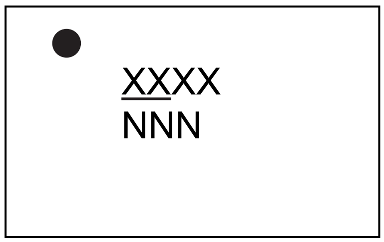


FIGURE 6-2: *V_{DD} Decoupling for Very Noisy Supplies.*

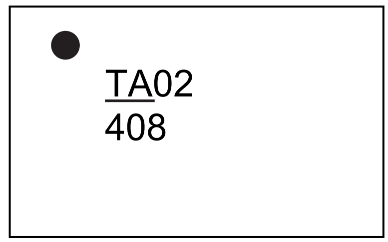
7.0 PACKAGING INFORMATION

7.1 Package Marking Information

6-Pin SOT23*



Example



Legend:

XX...X	Product code or customer-specific information
Y	Year code (last digit of calendar year)
YY	Year code (last 2 digits of calendar year)
WW	Week code (week of January 1 is week '01')
NNN	Alphanumeric traceability code
(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.

●, ▲, ▼ Pin one index is identified by a dot, delta up, or delta down (triangle mark).

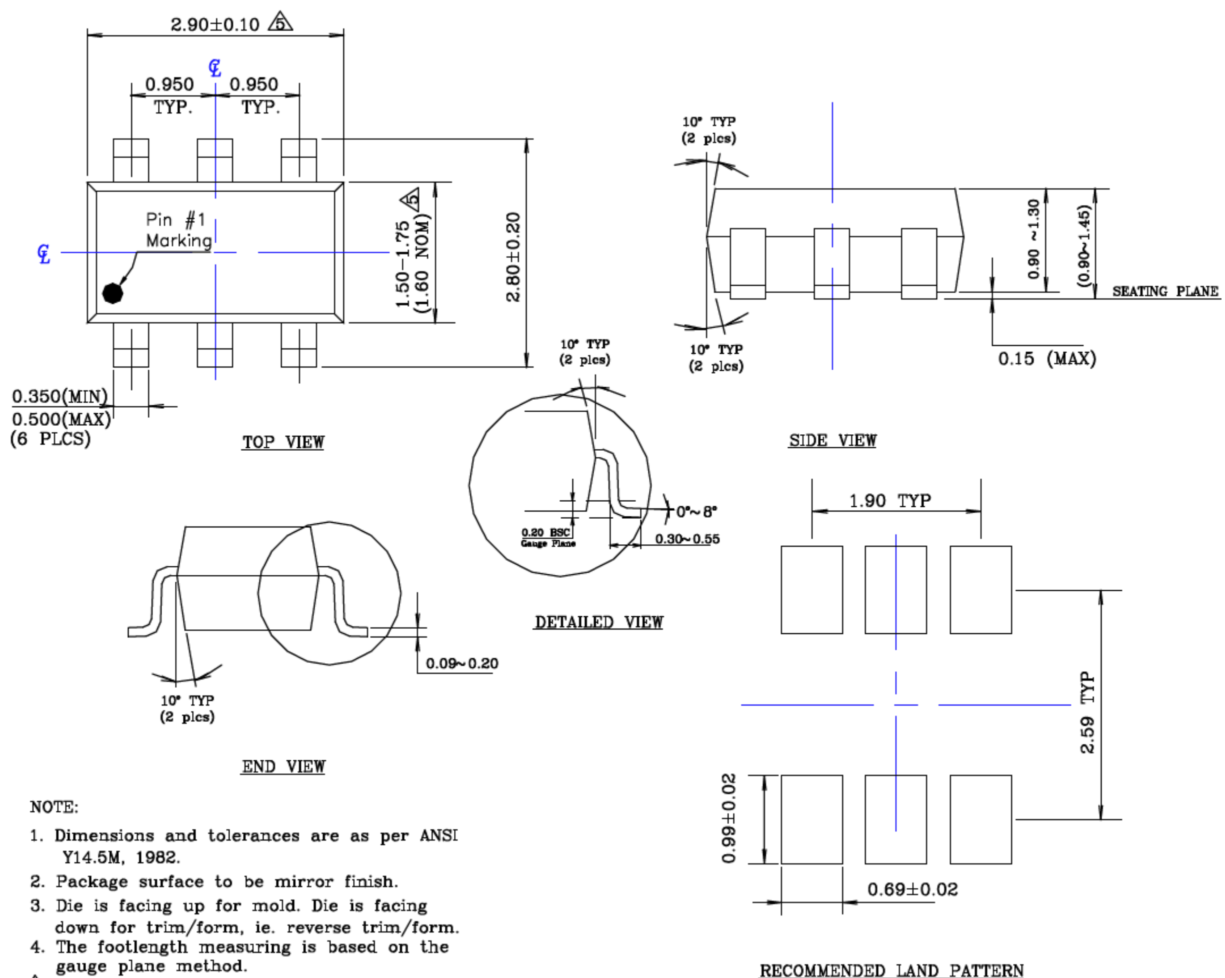
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

Underbar (_) and/or Overbar (‾) symbol may not be to scale.

6-Lead SOT-23 Package Outline and Recommended Land Pattern

TITLE
6 LEAD SOT23 PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	SOT23-6LD-PL-1	UNIT	MM



NOTE:

1. Dimensions and tolerances are as per ANSI Y14.5M, 1982.
2. Package surface to be mirror finish.
3. Die is facing up for mold. Die is facing down for trim/form, ie. reverse trim/form.
4. The footlength measuring is based on the gauge plane method.

⚠5 Dimension are exclusive of mold flash & gate burr.

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging.

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (November 2020)

- Converted Micrel data sheet MIC280 to Microchip data sheet DS20006458A.
- Minor grammatical corrections throughout.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

PART NO.	-X	X	XX	-XX
Device	Client Address	Temperature Range	Package	Media Type

Device: MIC280: Precision IttyBitty Thermal Supervisor

Client Address:
0 = 100 1000_b
1 = 100 1001_b
2 = 100 1010_b
3 = 100 1011_b
4 = 100 1100_b
5 = 100 1101_b
6 = 100 1110_b
7 = 100 1111_b

Temperature: Y = –55°C to +125°C

Package: M6 = SOT23-6

Media Type
TX = 3,000/Reel (Reverse Tape & Reel)
TR = 3,000/Reel

Examples:

a) MIC280-0YM6-TR: Precision IttyBitty Thermal Supervisor, 100 1000_b Client Address, –55°C to +125°C Temperature Range, SOT23-6 Package, 3,000/Reel

b) MIC280-0YM6-TX:Precision IttyBitty Thermal Supervisor, 100 1000_b Client Address, –55°C to +125°C Temperature Range, SOT23-6 Package, 3,000/Reel (Reverse Tape & Reel)

c) MIC280-1YM6-TR: Precision IttyBitty Thermal Supervisor, 100 1001_b Client Address, –55°C to +125°C Temperature Range, SOT23-6 Package, 3,000/Reel

d) MIC280-1YM6-TX:Precision IttyBitty Thermal Supervisor, 100 1001_b Client Address, –55°C to +125°C Temperature Range, SOT23-6 Package, 3,000/Reel (Reverse Tape & Reel)

e) MIC280-2YM6-TR: Precision IttyBitty Thermal Supervisor, 100 1010_b Client Address, –55°C to +125°C Temperature Range, SOT23-6 Package, 3,000/Reel

f) MIC280-2YM6-TX:Precision IttyBitty Thermal Supervisor, 100 1010_b Client Address, –55°C to +125°C Temperature Range, SOT23-6 Package, 3,000/Reel (Reverse Tape & Reel)

g) MIC280-3YM6-TR: Precision IttyBitty Thermal Supervisor, 100 1011_b Client Address, –55°C to +125°C Temperature Range, SOT23-6 Package, 3,000/Reel

h) MIC280-3YM6-TX:Precision IttyBitty Thermal Supervisor, 100 1011_b Client Address, –55°C to +125°C Temperature Range, SOT23-6 Package, 3,000/Reel (Reverse Tape & Reel)

i) MIC280-4YM6-TR: Precision IttyBitty Thermal Supervisor, 100 1100_b Client Address, –55°C to +125°C Temperature Range, SOT23-6 Package, 3,000/Reel

j) MIC280-4YM6-TX:Precision IttyBitty Thermal Supervisor, 100 1100_b Client Address, –55°C to +125°C Temperature Range, SOT23-6 Package, 3,000/Reel (Reverse Tape & Reel)

k) MIC280-5YM6-TR: Precision IttyBitty Thermal Supervisor, 100 1101_b Client Address, –55°C to +125°C Temperature Range, SOT23-6 Package, 3,000/Reel

l) MIC280-5YM6-TX:Precision IttyBitty Thermal Supervisor, 100 1101_b Client Address, –55°C to +125°C Temperature Range, SOT23-6 Package, 3,000/Reel (Reverse Tape & Reel)

NOTES:

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