

1°C Triple Temperature Sensor with Hotter of Two Zones

PRODUCT FEATURES

Datasheet

General Description

The EMC1063 is a family of System Management Bus (SMBus) temperature sensors that monitors three temperature zones, one internal diode and two externally connected diodes. The EMC1063 is specifically designed to operate with AMD processor diodes. Alternately, the External Diode 2 channel can be configured to measure a standard thermal diode (such as a 2N3904) with Resistive Error Correction active.

An added feature to the EMC1063 is a function that automatically compares the two external temperature zones and reports the hotter of the two temperatures. Selectable conversion rates and standby mode support low-power operation. The temperature measurement ranges support two data ranges (and formats), -64°C to +127°C and -64°C to +191°C.

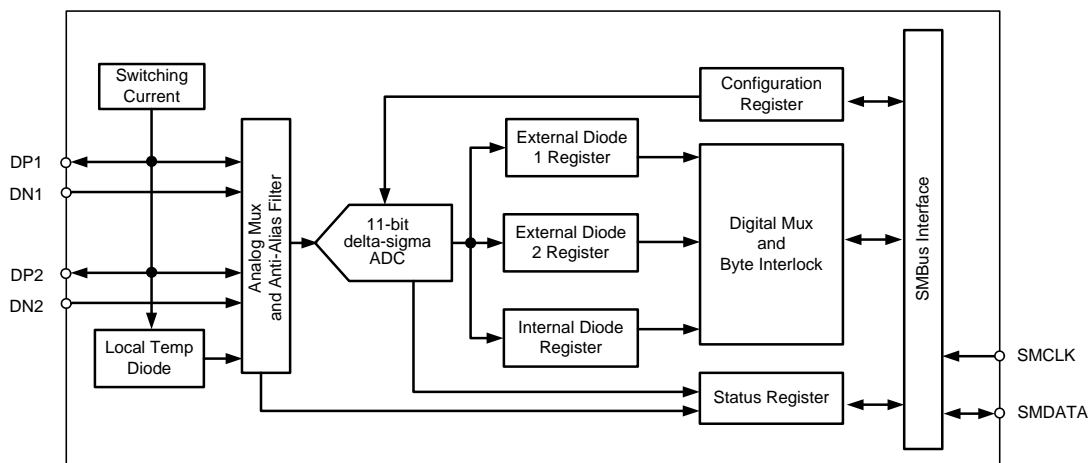
Applications

- Desktop and Notebook Computers
- Hardware Management
- Servers
- Embedded Applications

Features

- Designed to Operate with AMD Processor Diodes
- Supports two External Temperature Diodes
 - $\pm 1^\circ\text{C}$ Accuracy (40°C to 80°C)
 - 0.125°C Resolution
 - Ideality Factor Configuration
 - Accepts 2200pF Cap Across External Diodes for Noise Suppression
 - Optional Resistive Error Correction on External Diode 2
- Internal Temperature Diode
 - $\pm 3^\circ\text{C}$ Accuracy (0°C to 85°C)
 - 0.125°C Resolution
- Low Power Operation
 - 4uA Standby Current
- 3.0V to 3.6V Supply
- Programmable Conversion Rate
- SMBus 2.0 Compliant
 - Four SMBus Address Available
- Reports Hotter of Two Diodes with Dual-core CPU

Simplified Block Diagram



ORDERING INFORMATION

| ORDERING NUMBER | PACKAGE | FEATURES | SMBUS ADDRESS |
|-------------------|---|---|---------------|
| EMC1063-1-ACZL-TR | 8 pinMSOP package (Lead Free ROHS compliant) | Two External Diodes with Hottest Of Comparison | 1001_100x |
| EMC1063-2-ACZL-TR | | | 1001_101x |
| EMC1063-3-ACZL-TR | | | 1001_000x |
| EMC1063-4-ACZL-TR | | | 1001_001x |

Reel size is 4,000 pieces.

Evaluation board available upon request (EVB-EMC1063)



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Chapter 1 Pin Function

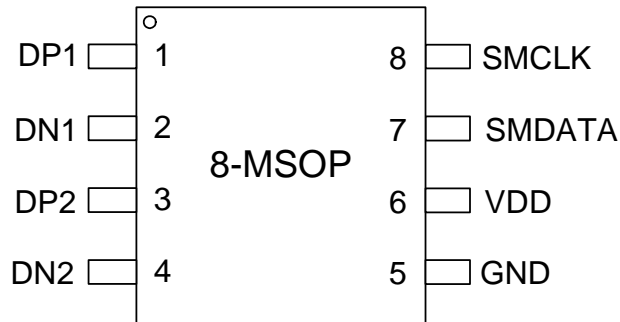


Figure 1.1 EMC1063 Pin Diagram

Table 1.1 EMC1063 Pin Description

| PIN | PIN NO. | DESCRIPTION |
|--------|---------|---|
| DP1 | 1 | External Diode 1 Positive (anode) Connection |
| DN1 | 2 | External Diode 1 Negative (cathode) Connection |
| DP2 | 3 | External Diode 2 Positive (anode) Connection |
| DN2 | 4 | External Diode 2 Negative (cathode) Connection |
| GND | 5 | Ground |
| VDD | 6 | Supply Voltage |
| SMDATA | 7 | System Management Bus Data - bi-directional data, open drain output |
| SMCLK | 8 | System Management Bus Clock Input |

Chapter 2 Electrical Specifications

2.1 Absolute Maximum Ratings

Table 2.1 Absolute Maximum Ratings

| DESCRIPTION | RATING | UNIT |
|---|--------------------------------|------|
| Supply Voltage V_{DD} | -0.3 to 5.0 | V |
| Voltage on SMDATA and SMCLK pins | -0.3 to 5.5 | V |
| Voltage on any other pin | -0.3 to $V_{DD}+0.3$ | V |
| Operating Temperature Range | -40 to 125 | °C |
| Storage Temperature Range | -55 to 150 | °C |
| Lead Temperature Range | Refer to JEDEC Spec. J-STD-020 | |
| Package Thermal Characteristics for MSOP-8 | | |
| Thermal Resistance T_{JA} (at 0 air flow) | 135.9 | °C/W |
| ESD Rating, All Pins Human Body Model | 2000 | V |

Note: Stresses above those listed could cause damage to the device. This is a stress rating only and functional operation of the device at any other condition above those indicated in the operation sections of this specification is not implied. When powering this device from laboratory or system power supplies, it is important that the Absolute Maximum Ratings not be exceeded or device failure can result. Some power supplies exhibit voltage spikes on their outputs when the AC power is switched on or off. In addition, voltage transients on the AC power line may appear on the DC output. If this possibility exists, it is suggested that a clamp circuit be used.

2.2 Electrical Specifications

Table 2.2 Electrical Characteristics

| $V_{DD}=3.0V$ to $3.6V$, $T_A = -20^{\circ}C$ to $+85^{\circ}C$, Typical values at $T_A = 27^{\circ}C$ unless otherwise noted | | | | | | |
|---|------------|-----|---------|-----------|---------|--|
| PARAMETER | SYMBOL | MIN | TYP | MAX | UNITS | CONDITIONS |
| DC Power | | | | | | |
| Supply Voltage | V_{DD} | 3.0 | 3.3 | 3.6 | V | |
| Average Operating Current | I_{DD} | | 340 | 400 | μA | 4 conversions/s See Table 4.4 . |
| | I_{STBY} | | 2 | 4 | μA | Standby mode |
| Internal Temperature Monitor | | | | | | |
| Temperature Accuracy | | | ± 1 | ± 3 | °C | $-20^{\circ}C \leq T_A \leq 85^{\circ}C$ |
| | | | | ± 1.5 | °C | $0^{\circ}C < T_A \leq 85^{\circ}C$ |
| Temperature Resolution | | | 0.125 | | °C | |

Table 2.2 Electrical Characteristics (continued)

| V _{DD} =3.0V to 3.6V, T _A = -20°C to +85°C, Typical values at T _A = 27°C unless otherwise noted | | | | | | |
|--|----------------------------------|------|-------|---------------------------------|----------------|--|
| PARAMETER | SYMBOL | MIN | TYP | MAX | UNITS | CONDITIONS |
| External Temperature Monitor | | | | | | |
| Temperature Accuracy Remote Diode 40°C to 80°C Remote Diode -20°C to 125°C Remote Diode -64°C to 192°C | | | | ± 1 ± 3 ± 5 | °C °C °C | 15°C ≤ T _A ≤ 70°C -20°C ≤ T _A ≤ 85°C -20°C ≤ T _A ≤ 85°C |
| Temperature Resolution | | | 0.125 | | °C | |
| Filter Capacitor | C _{FILTER} | | | 2.2 | nF | Connected across external diode Note 2.2 |
| Voltage Tolerance | | | | | | |
| Voltage at pin (SMDATA,SMCLK) | V _{TOL} | -0.3 | | 5.5 | V | |
| SMBus Interface (SMDATA,SMCLK) | | | | | | |
| Input High Level | V _{IH} | 2.0 | | | V | |
| Input Low Level | V _{IL} | | | 0.8 | V | |
| Input High/Low Current | I _{IH} /I _{IL} | -1 | | 1 | μA | |
| Hysteresis | | | 500 | | mV | |
| Input Capacitance | | | 5 | | pF | |
| Output Low Sink Current | | 6 | | | mA | SMDATA = 0.6V |
| SMBus Timing | | | | | | |
| Clock Frequency | F _{SMB} | 10 | | 400 | kHz | |
| Spike Suppression | | | | 50 | ns | |
| Bus free time Start to Stop | T _{BUF} | 1.3 | | | μs | |
| Hold time Start | T _{HD:STA} | 0.6 | | | μs | |
| Setup time Start | T _{SU:STA} | 0.6 | | | μs | |
| Setup time Stop | T _{SU:STO} | 0.6 | | | μs | |
| Data Hold Time | T _{HD:DAT} | 0.3 | | | μs | |
| Data Setup Time | T _{SU:DAT} | 100 | | | ns | |
| Clock Low Period | T _{LOW} | 1.3 | | | μs | |
| Clock High Period | T _{HIGH} | 0.6 | | | μs | |
| Clock/Data Fall Time | T _F | * | | 300 | ns | *Min = 20+0.1C _b ns |
| Clock/Data Rise Time | T _R | * | | 300 Note 2.1 | ns | *Min = 20+0.1C _b ns |
| Capacitive Load (each bus line) | C _b | 0.6 | | 400 | pF | |

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- Note 2.1** 300nS rise time max is required for 400kHz bus operation. For lower clock frequencies, the maximum rise time is $(0.1/F_{SMB})+50nS$
- Note 2.2** See SMSC Applications for Application Notes and Guidelines when measuring GPU processor diodes and CPU processor diodes.

2.3 System Management Bus Interface Protocol

A host controller, such as an SMSC I/O controller, communicates with the EMC1063 via the two wire serial interface named SMBus. The SMBus interface is used to read and write registers in the EMC1063, which is a slave-only device. A detailed timing diagram is shown in [Figure 2.1](#).

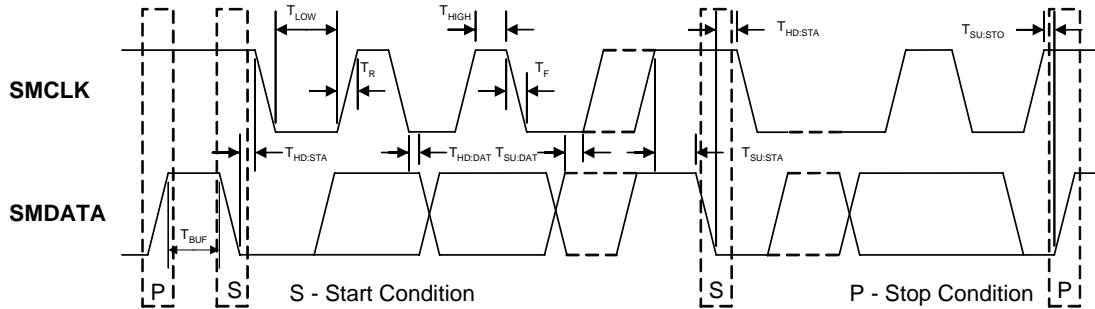


Figure 2.1 System Management Bus Timing Diagram

The EMC1063 implements a subset of the SMBus specification and supports Write Byte, Read Byte, Send Byte, and Receive Byte protocols as shown. In the tables that describe the protocol, the “gray” columns indicate that the slave is driving the bus.

All of the below protocols use the following convention:

| DATA SENT TO DEVICE | DATA SENT TO THE HOST |
|---------------------|-----------------------|
| # of bits sent | # of bits sent |

2.3.1 Write Byte

The Write Byte is used to write one byte of data to the registers as shown in [Table 2.3](#).

Table 2.3 Write Byte Protocol

| START | SLAVE ADDRESS | WR | ACK | COMMAND | ACK | DATA | ACK | STOP |
|-------|---------------|----|-----|---------|-----|------|-----|------|
| 1 | 7 | 1 | 1 | 8 | 1 | 8 | 1 | 1 |

2.3.2 Read Byte

The Read Byte protocol is used to read one byte of data from the registers as shown in [Table 2.4](#).

Table 2.4 Read Byte Protocol

| START | SLAVE ADDRESS | WR | ACK | COMMAND | ACK | START | SLAVE ADDRESS | RD | ACK | DATA | NACK | STOP |
|-------|---------------|----|-----|---------|-----|-------|---------------|----|-----|------|------|------|
| | | | | | | | | | | | | |

Table 2.4 Read Byte Protocol

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7 | 1 | 1 | 8 | 1 | 1 | 7 | 1 | 1 | 8 | 1 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

2.3.3 Send Byte

The Send Byte protocol is used to set the Internal Address Register to the correct Address as shown in [Table 2.5](#). The Send Byte can be followed by the Receive Byte protocol described in [Table 2.6](#) to read data from the register. The send byte protocol cannot be used to write data - if data is to be written to a register then the write byte protocol must be used as described in [Section 2.3.1](#).

Table 2.5 Send Byte Protocol

| START | SLAVE ADDR | WR | ACK | REG. ADDR | ACK | STOP |
|-------|------------|----|-----|-----------|-----|------|
| 1 | 7 | 1 | 1 | 8 | 1 | 1 |

2.3.4 Receive Byte

The Receive Byte protocol is used to read data from a register when the internal register address pointer is known to be at the right location (e.g. set via Send Byte). This can be used for consecutive reads of the same register as shown in [Table 2.6](#).

Table 2.6 Receive Byte Protocol

| START | SLAVE ADDR | RD | ACK | REG. DATA | NACK | STOP |
|-------|------------|----|-----|-----------|------|------|
| 1 | 7 | 1 | 1 | 8 | 1 | 1 |

2.3.5 SMBus Timing Diagram

The Timing for the SMBus is shown in [Figure 2.1](#).

2.4 SMBus Addresses

The EMC1063 may be ordered with one of four slave addresses as shown in [Ordering Information](#). Attempting to communicate with the EMC1063 SMBus interface with an invalid slave address or invalid protocol results in no response from the device and does not affect its register contents. The EMC1063 supports stretching of the SMCLK signal by other devices on the SMBus but will not perform this operation itself.

2.5 SMBus Timeout

The EMC1063 includes an SMBus time-out feature. Following a 25 ms period of inactivity on the SMBus, the device will time-out and reset the SMBus interface.

Chapter 3 Product Description

The EMC1063 is an SMBus sensor that monitors three temperature zones for use in a personal computer or embedded environment. The part may be used as a companion to one of SMSC's broad line of SIO host devices to perform fan control and thermal management.

The EMC1063 is designed to operate with two AMD thermal diodes. The External diode 2 channel can be configured with the Resistance Error Correction feature enabled to measure a discrete 2N3904 diode. A typical system is shown in [Figure 3.1](#).

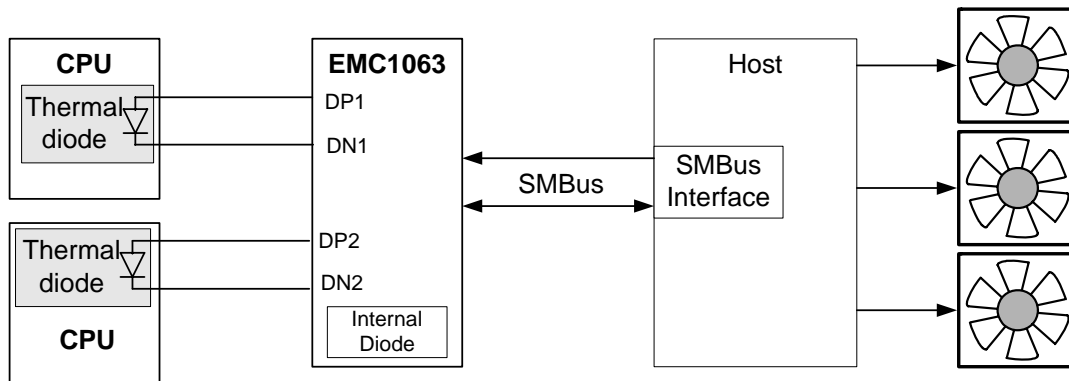


Figure 3.1 EMC1063 Diode System

3.1 Power Modes

The EMC1063 has two power modes.

- Run Mode - In this mode, the temperature monitors are active and converting at the programmed conversion rate. The average power dissipation will depend on the conversion rate. When the EMC1063 is not actively converting a channel, it goes into a lower power wait state.
- Standby Mode (power-up default) - in this mode, the EMC1063 is put into a low power state. In the standby mode, temperature monitoring is disabled. The device will still respond to SMBus commands.

3.2 One Shot During Standby Mode

The EMC1063 supports a One-Shot command when it is in Standby Mode. Writing to the One-Shot register will cause the device to power up, perform 1 full set of temperature conversions, then return to Standby Mode.

3.3 Operation During Run Mode

When the device is active, there are two modes of operation available.

- Normal Mode (power-up default) - In this mode of operation, the EMC1063 continuously samples and updates all of its temperature channels.
- Hotter of Two Mode - In this mode, the EMC1063 continuously samples and then compares the two remote zones. The hotter of the two remote zones is loaded into the External Diode 2 Data Registers. In addition, the HOTTER bit in the Status register is set or cleared to indicate which external diode zone is hotter. If the two remote zones are exactly equal to each other, then the

HOTTER bit is cleared (set to '0'), and the results of the two remote zones are stored in their respective registers.

3.3.1 Conversion Rates

The EMC1063 may be configured for different conversion rates based on the system requirements. The available rates are 1 full set of conversions per second to 16 full sets of conversions per second. The conversion rate is configured as described in [Section 4.4](#). The available conversion rates are shown in [Table 4.4](#).

3.3.2 Dynamic Averaging

The EMC1063 temperature channels support a new feature that measures the external diode channels for an extended time based on the selected conversion rate. This functionality can be disabled as described in [Section 4.5](#) for increased power savings at the lower conversion rates. When Dynamic Averaging is enabled, the device will automatically adjust the sampling and measurement time for both external diode channels. This allows the device to average 2x or 4x longer than the normal 11 bit operation while still maintaining the selected conversion rate. The benefits of Dynamic Averaging are improved noise rejection due to the longer integration time as well as less random variation on the temperature measurement.

The Dynamic Averaging applies when a One-Shot command is issued. The device will perform the desired averaging during the one-shot operation according to the selected conversion rate.

The Dynamic Averaging will affect the average supply current based on the chosen conversion rate as shown in [Table 3.1](#).

Table 3.1 Supply Current vs. Conversion Rate and ADC Averaging Factor

| CONVERSION RATE | ADC AVERAGING FACTOR | | |
|-----------------|-----------------------------------|-----------------------------------|------------------|
| | 4X (MAX_RES = 1) (DA_N = 0) | 2X (MAX_RES = 0) (DA_N = 0) | 1X (DA_N = 1) |
| 1 / sec | 190uA | 132uA | 105uA |
| 2 / sec | 315uA | 205uA | 150uA |
| 4 / sec | 580uA | 350uA | 235uA |
| 8 / sec | N/A | 640uA | 405uA |
| 16 / sec | N/A | N/A | 750uA |

3.4 Temperature Monitors

In general, thermal diode temperature measurements are based on the change in forward bias voltage of a diode when operated at two different currents. This ΔV_{BE} is then proportional to absolute temperature as shown in the following equation:

$$\Delta V_{BE} = V_{BE_HIGH} - V_{BE_LOW} = \frac{\eta k T}{q} \ln \left(\frac{I_{HIGH}}{I_{LOW}} \right)$$

where:

k = Boltzmann's constant

T = absolute temperature in Kelvin

q = electron charge

η = diode ideality factor

[1]

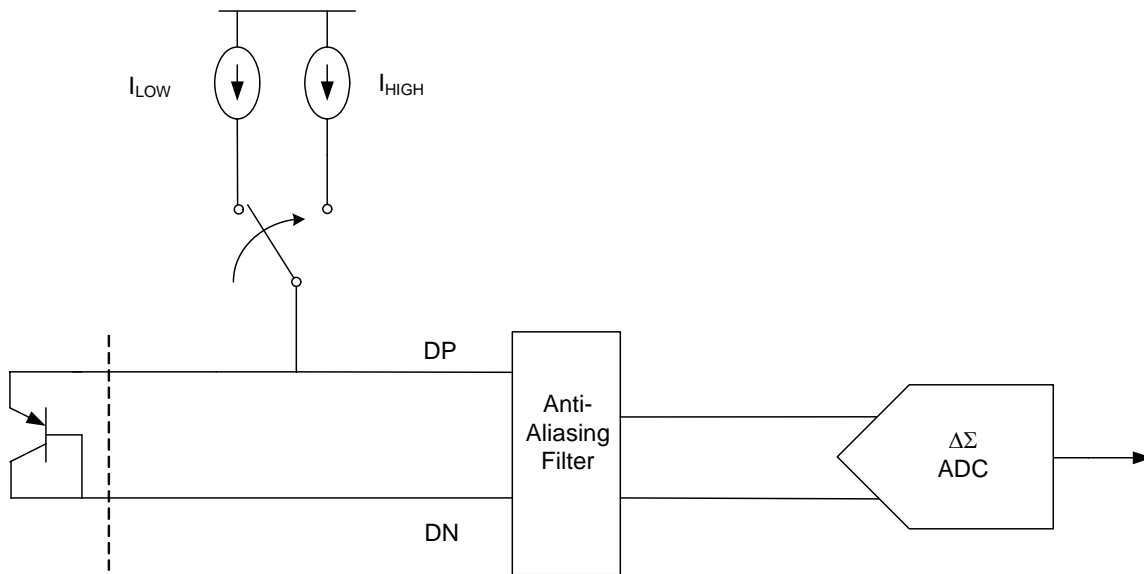


Figure 3.2 Block Diagram of Temperature Monitoring Circuit

Figure 3.2 shows a block diagram of the temperature measurement circuit. The negative terminal for the remote temperature diode, DN, is internally biased with a forward diode voltage referenced to ground.

The External Diode 2 channel in the EMC1063 is compatible with a broad range of thermal diode, including those found in AMD processors, that may be connected as shown in Figure 3.3.

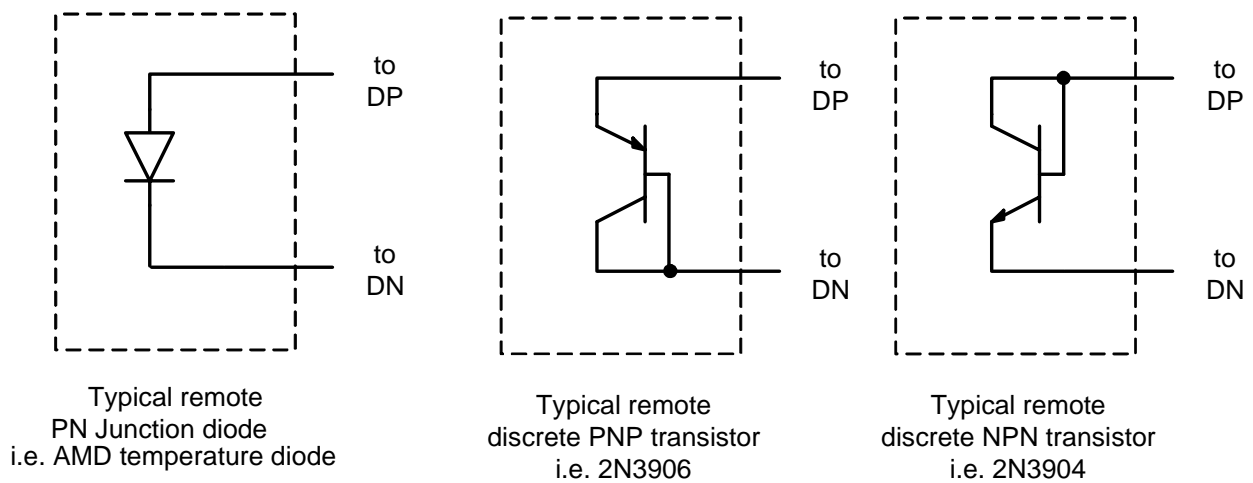


Figure 3.3 External Diode Configurations

3.5 Temperature Measurement Results and Data

Each temperature result for each zone is available in two byte wide data registers. As shown in [Section 4.1](#), the 11-bit format has the 8 most significant bits stored in the high byte register and the 3 least significant bits stored in the three MSB positions of the low byte register. The delta-sigma ADC may be operated with more than 11 bits of resolution for improved averaging as described in [Section 4.5](#), but the temperature result is reported at 11-bit resolution.

The temperature results for the two remote zones are also stored in extended format with a range from -64°C to +191°C. The data format is a 2's complement number offset by 64°C as shown in [Section 4.2](#). The data for each of the remote zones in both legacy and extended format is stored in separate data registers so that both data formats are always available. [Table 3.2](#) shows the default and extended range formats.

Table 3.2 EMC1063 Temperature Data Format

| TEMPERATURE (°C) | RANGE -64°C TO 127°C | RANGE -64°C TO 191°C |
|------------------|----------------------|----------------------|
| | BINARY | OFFSET BINARY |
| Diode Fault | 100 0000 0000 | 100 0000 0000 |
| <= -64 | 110 0000 0000 | 100 0000 0000 |
| -63.875 | 110 0000 0001 | 100 0000 0001 |
| -63 | 110 0000 1000 | 100 0000 1000 |
| -1 | 111 1111 1000 | 101 1111 1000 |
| 0 | 000 0000 0000 | 110 0000 0000 |
| 0.125 | 000 0000 0001 | 110 0000 0001 |
| 1 | 000 0000 1000 | 110 0000 1000 |
| 64 | 010 0000 0000 | 000 0000 0000 |
| 65 | 010 0000 1000 | 000 0000 1000 |
| 127 | 011 1111 1000 | 001 1111 1000 |
| 127.875 | 011 1111 1111 | 001 1111 1111 |
| 128 | 011 1111 1111 | 010 0000 0000 |
| 191 | 011 1111 1111 | 011 1111 1000 |
| >= 191.875 | 011 1111 1111 | 011 1111 1111 |

3.6 Resistance Error Correction (REC)

Resistance error correction is an optional feature in the EMC1063 that eliminates the need to characterize and compensate for series resistance in the External Diode 2 lines. The EMC1063 corrects for as much as 100 ohms of series resistance.

When using a temperature sensor that does not include resistance error correction, voltage developed across the parasitic resistance in the external diode path produces an error in the reported temperature. The error introduced by this resistance is approximately +0.7°C per ohm. Sources of series resistance are PCB trace resistance, on die (i.e. on the processor) metal resistance, bulk resistance in the base and emitter of the temperature transistor.

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The External Diode 1 channel has the REC functionality disabled for use in monitoring an AMD K8 processor. The External Diode 2 channel defaults to REC functionality disabled but can be enabled by writing to the Configuration 2 Register (see [Section 4.5](#)). If the External Diode 2 channel is connected as a diode-connected transistor as shown in [Figure 3.3](#), resistance error correction should be enabled to minimize series resistance and improve accuracy

3.7 Programmable Ideality Factor

The EMC1063 default is for a diode ideality factor of 1.008 which is common for a 2N3904 diode and for many processor transistors. When a diode or transistor is used that has a different ideality factor value than 1.008 a temperature error is induced that is a linear function of temperature. Previous solutions for this mismatch in ideality factor has been to supply a programmable offset to the temperature reading which corrects the error at a single temperature but causes a residual error at all other temperatures. The EMC1063 ideality factor register corrects this mismatch error at all temperatures (see [Section 4.7](#)).

APPLICATION NOTE: When monitoring a substrate transistor or CPU diode and beta compensation is enabled, the Ideality Factor should not be adjusted. Beta Compensation automatically corrects for most ideality errors.

3.8 Diode Faults

The EMC1063 detects a fault if the DP pin is left floating or is shorted to VDD. In the case of a diode fault, the corresponding status bit will be set and the output data will be set at 400h.

Chapter 4 Register Set and Description

The following registers are accessible through the SMBus Interface.

Table 4.1 EMC1063 Register Set

| REGISTER ADDRESS | | R/W | REGISTER NAME | SYMBOL | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | DEFAULT VALUE |
|------------------|-------|-----|--|--------|------|------|-------|----|----|----|----|----|---------------|
| READ | WRITE | | | | | | | | | | | | |
| 00h | N/A | R | Internal Temperature High Byte - Legacy Format | INTHBL | Sign | 64 | 32 | 16 | 8 | 4 | 2 | 1 | 00h |
| 23h | N/A | R | Internal Temperature Low Byte - Legacy Format | INTLBL | 0.5 | 0.25 | 0.125 | | | | | | 00h |
| 01h | N/A | R | External Diode 1 High Byte - Legacy Format | ET1HBL | Sign | 64 | 32 | 16 | 8 | 4 | 2 | 1 | 00h |
| 10h | N/A | R | External Diode 1 Low Byte - Legacy Format | ET1LBL | 0.5 | 0.25 | 0.125 | | | | | | 00h |
| F8h | N/A | R | External Diode 2 High Byte - Legacy Format | ET2HBL | Sign | 64 | 32 | 16 | 8 | 4 | 2 | 1 | 00h |
| F9h | N/A | R | External Diode 2 Low Byte - Legacy Format | ET2LBL | 0.5 | 0.25 | 0.125 | | | | | | 00h |
| FAh | N/A | R | External Diode 1 High Byte - Extended Format | ET1HBE | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 | 00h |
| FBh | N/A | R | External Diode 1 Low Byte - Extended Format | ET1LBE | 0.5 | 0.25 | 0.125 | | | | | | 00h |
| FCh | N/A | R | External Diode 2 High Byte - Extended Format | ET2HBE | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 | 00h |

Table 4.1 EMC1063 Register Set (continued)

| REGISTER ADDRESS | | R/W | REGISTER NAME | SYMBOL | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | DEFAULT VALUE |
|--------------------|-------|-----|---|--------|--|----------|-------|--------|---------|---------|------|-----|---------------|
| READ | WRITE | | | | | | | | | | | | |
| FDh | N/A | R | External Diode 2 Low Byte - Extended Format | ET2LBE | 0.5 | 0.25 | 0.125 | | | | | | 00h |
| Status and Control | | | | | | | | | | | | | |
| 02h | N/A | R | Status | STS | Busy | - | - | HOTTER | - | - | D2 | D1 | 00h |
| 03h | 09h | R/W | Configuration | CFG | - | ADC_STOP | - | - | - | CR<2:0> | | | 45h |
| 04h | 04h | R/W | Configuration 2 | CFG2 | - | - | - | - | MAX_RES | DA_n | COMP | REC | 08h |
| One Shot | | | | | | | | | | | | | |
| N/A | 0Fh | W | One Shot Conversion | Shot | The data written to this register is irrelevant and will not be stored | | | | | | | 00h | |
| Ideality | | | | | | | | | | | | | |
| 27h | 27h | R/W | External Diode 1 Ideality Correction Factor | IDCF1 | - | - | B5 | B4 | B3 | B2 | B1 | B0 | 12h (1.008) |
| 28h | 28h | R/W | External Diode 2 Ideality Correction Factor | IDCF2 | - | - | B5 | B4 | B3 | B2 | B1 | B0 | 12h (1.008) |
| EDh | EDh | R | Product ID | PID | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 30h (-1) |
| | | | | | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 31h (-2) |
| | | | | | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 32h (-3) |
| | | | | | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 33h (-4) |
| FEh | FEh | R | Manufacturer ID | SMSC | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 5Dh |
| FFh | FFh | R | Revision Register | REV | - | - | - | - | 0 | 0 | 0 | 1 | 01h |

During Power on Reset (POR), the default values are stored in the registers. A POR is initiated when power is first applied to the part and the voltage on the VDD supply surpasses the POR level as specified in the electrical characteristics. Any reads to undefined registers will return 00h. Writes to undefined registers will not have an effect.

The EMC1063 uses an interlock mechanism that will update the Low byte of a particular monitor when the High Byte is read. This prevents changes in register content when the ADC updates between successive reads.

4.1 Legacy Temperature Data Registers (00h, 23h, 01h, 10h, F8h, F9h)

As shown in [Table 4.1](#), each temperature monitor has two data registers. The 11 bit temperature data is stored aligned to the left resulting in the High Byte containing temperature in 1°C steps and the Low Byte containing fractions of a degree.

4.2 Extended Format Temperature Registers (FAh-FDh)

The Extended Format Temperature Registers store only the external diode temperatures in the extended data format. This is because, due to the operating range limitations of the EMC1063, the internal temperature could not benefit from the extended temperature range. Like the Legacy data formatting, the data is stored in two registers per temperature channel.

4.3 Status Register - 02h

Table 4.2 Status Register

| ADDR | REGISTER | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | DEFAULT |
|------|----------|------|----|----|--------|----|----|----|----|---------|
| 02h | Status | Busy | - | - | HOTTER | - | - | D2 | D1 | 00h |

The Status Register is a read only register and returns the operational status of the part. External diode faults are indicated by bits 1 and 0. If either bit is set to '1', then a diode fault has occurred. When a diode fault occurs, the D1 or D2 status bit is set, but otherwise the data remains unchanged.

Bit 7 - Busy - indicates that the ADC is currently converting a temperature.

Bit 4 - HOTTER - during Hotter of Two mode, this bit indicates which of the external diode channels is hotter. If this bit is '0', then External Diode 1 is hotter or equal to External Diode 2. If this bit is '1', then External Diode 2 is hotter than External Diode 1. During normal operation, this bit will always read a '0'.

Bit 1 - D2 - indicates that a diode fault has occurred on External Diode 2.

Bit 0 - D1 - indicates that a diode fault has occurred on External Diode 1.

4.4 Configuration Register (03h Read, 09h Write)

Table 4.3 Configuration Register

| ADDR | REGISTER | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | DEFAULT |
|------------------------|----------|----|---------|----|----|----|---------|----|----|---------|
| 03h Read, 09h Write | Config | - | STANDBY | - | - | - | CR<2:0> | | | 45h |

Datasheet

The Configuration Register controls the basic functionality of the EMC1063. The bits are described below:

Bit 6 - STANDBY- controls the ADC conversions and power modes of the part.

- '0' - The device is in the run operating mode. The ADC is converting at the user-programmed conversion rate.
- '1' - (default) The device is in the standby operating mode (see [Section 3.1](#)).

Bit 2-0 - CR<2:0> - determines the conversion rate for the temperature monitoring per [Table 4.4](#).

Table 4.4 Conversion Rate

| CR<2:0> | | | CONVERSIONS / SECOND (CONVERSION TIME) |
|---------|---|---|---|
| 2 | 1 | 0 | |
| 0 | 0 | 0 | Reserved |
| 0 | 0 | 1 | Reserved |
| 0 | 1 | 0 | Reserved |
| 0 | 1 | 1 | 1 Conversion / sec |
| 1 | 0 | 0 | 2 Conversions / sec |
| 1 | 0 | 1 | 4 Conversions / sec (default) |
| 1 | 1 | 0 | 8 Conversions / sec |
| 1 | 1 | 1 | 16 Conversions / sec |

4.5 Configuration 2 Register - (04h)

Table 4.5 Configuration 2 Register

| ADDR | REGISTER | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | DEFAULT |
|------|----------|----|----|----|----|---------|------|------|-----|---------|
| 04h | CFG2 | - | - | - | - | MAX_RES | DA_n | COMP | REC | 08h |

The Configuration 2 Register controls the basic functionality of the EMC1063 that is NOT compatible with the EMC1023.

Bit 3 - MAX_RES - controls the external diode conversion time during dynamic averaging. Although the dynamic averaging may be used to increase the ADC resolution, only 11 bits of data are available in the temperature registers.

- '0' - the dynamic averaging will set the ADC averaging factor at 1x when the conversion rate is set at 16 conversions per second and 2x at conversion rates lower than 16 per second.
- '1' (default) - the dynamic averaging will set the ADC averaging factor at 1x when the conversion rate is set at 16 conversions per second, 2x at 8 conversions / second and 4x at conversion rates lower than 8 per second.

Bit 2 - DA_n - controls the dynamic digital averaging circuitry. See [Section 3.3.2](#).

- '0' (default) - dynamic averaging is enabled. Depending on the selected conversion rate, the ADC averaging factor is increased for the external diodes.

- '1' - dynamic averaging is disabled. The ADC averaging factor will remain fixed at 1x for all conversion rates and will allow increased power savings at the slower conversion rates.

Bit 1 - COMP - configures the device to perform a comparison for the Hotter of Two mode (see [Section 3.3, "Operation During Run Mode,"](#) on page 11.)

- '0' (default) - the device is in normal mode
- '1' - the device is in Hotter of Two mode. In this mode, the two external diode channels are measured and compared against each other. The hotter of the two channels has its data loaded into the External Diode 2 Data Registers. The Internal Diode and External Diode 1 Data Registers remain unaffected.

Bit 0 - REC - controls the Resistance Error Correction circuitry

- '0' (default)- The Resistance Error Correction circuitry is disabled.
- '1' - The Resistance Error Correction circuitry is active and will automatically correct for up to 100 ohms of series resistance in the diode lines for the External Diode 2channel.

4.6 One Shot Register - (0Fh)

Table 4.6 One Shot Registers

| ADDR | REGISTER | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | DEFAULT |
|------|---------------------|--|----|----|----|----|----|----|----|---------|
| 0Fh | One Shot Conversion | Writing to this register address initiates the one-shot. The data is not important and is not stored | | | | | | | | 00h |

The One Shot Register is an address place holder for the one-shot command. Writing to the address initiates the command. The data written is not important and is not stored. Reading from the one-shot registers will always return 00h.

4.7 Ideality Configuration Registers (27h - 28h)

Table 4.7 Ideality Configuration Registers

| ADDR | REGISTER | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | DEFAULT |
|------|------------------------------------|----|----|----|----|----|----|----|----|----------------|
| 27h | Diode 1 Ideality Correction Factor | - | - | B5 | B4 | B3 | B2 | B1 | B0 | 12h (1.008) |
| 28h | Diode 2 Ideality Correction Factor | - | - | B5 | B4 | B3 | B2 | B1 | B0 | 12h (1.008) |

The Ideality Configuration Registers store the ideality correction factor that is applied to each external diode.

The table below shows the ideality factor settings for the Ideality Configuration registers. Shading indicates power-up default. All codes that are not listed are reserved and should not be used.

Beta Compensation and Resistance Error Correction automatically correct for most diode ideality errors, therefore it is not recommended that these settings be updated without consulting SMSC.

Table 4.8 Ideality Factor Look Up Table

| SETTING | FACTOR | SETTING | FACTOR | SETTING | FACTOR |
|---------|--------|---------|--------|---------|--------|
| 001000 | 0.9951 | 011000 | 1.0159 | 101000 | 1.0377 |
| 001001 | 0.9964 | 011001 | 1.0173 | 101001 | 1.0391 |
| 001010 | 0.9976 | 011010 | 1.0186 | 101010 | 1.0404 |
| 001011 | 0.9989 | 011011 | 1.0199 | 101011 | 1.0418 |
| 001100 | 1.0002 | 011100 | 1.0213 | 101100 | 1.0432 |
| 001101 | 1.0015 | 011101 | 1.0226 | 101101 | 1.0446 |
| 001110 | 1.0028 | 011110 | 1.0240 | 101110 | 1.0460 |
| 001111 | 1.0041 | 011111 | 1.0253 | 101111 | 1.0475 |
| 010000 | 1.0054 | 100000 | 1.0267 | 110000 | 1.0489 |
| 010001 | 1.0067 | 100001 | 1.0280 | 110001 | 1.0503 |
| 010010 | 1.0080 | 100010 | 1.0294 | | |
| 010011 | 1.0093 | 100011 | 1.0308 | | |
| 010100 | 1.0106 | 100100 | 1.0321 | | |
| 010101 | 1.0119 | 100101 | 1.0335 | | |
| 010110 | 1.0133 | 100110 | 1.0349 | | |
| 010111 | 1.0146 | 100111 | 1.0363 | | |

For CPU substrate transistors that require the BJT transistor model, the ideality factor behaves slightly differently than for discrete diode-connected transistors. Refer to [Table 4.9](#) when using a CPU substrate transistor.

Table 4.9 Substrate Diode Ideality Factor Look-Up Table (BJT Model)

| SETTING | FACTOR | SETTING | FACTOR | SETTING | FACTOR |
|---------|--------|---------|--------|---------|--------|
| 001000 | 0.9869 | 011000 | 1.0079 | 101000 | 1.0291 |
| 001001 | 0.9882 | 011001 | 1.0092 | 101001 | 1.0304 |
| 001010 | 0.9895 | 011010 | 1.0105 | 101010 | 1.0317 |
| 001011 | 0.9908 | 011011 | 1.0120 | 101011 | 1.0330 |
| 001100 | 0.9921 | 011100 | 1.0132 | 101100 | 1.0343 |
| 001101 | 0.9934 | 011101 | 1.0146 | 101101 | 1.0356 |
| 001110 | 0.9947 | 011110 | 1.0159 | 101110 | 1.0369 |
| 001111 | 0.9960 | 011111 | 1.0173 | 101111 | 1.0382 |
| 010000 | 0.9973 | 100000 | 1.0187 | 110000 | 1.0395 |

Table 4.9 Substrate Diode Ideality Factor Look-Up Table (BJT Model) (continued)

| SETTING | FACTOR | SETTING | FACTOR | SETTING | FACTOR |
|---------|--------|---------|--------|---------|--------|
| 010001 | 0.9986 | 100001 | 1.0200 | 110001 | 1.0408 |
| 010010 | 1.0000 | 100010 | 1.0213 | | |
| 010011 | 1.0013 | 100011 | 1.0226 | | |
| 010100 | 1.0026 | 100100 | 1.0239 | | |
| 010101 | 1.0039 | 100101 | 1.0252 | | |
| 010110 | 1.0053 | 100110 | 1.0265 | | |
| 010111 | 1.0066 | 100111 | 1.0278 | | |

APPLICATION NOTE: When measuring a 65nm Intel CPUs, the Ideality Setting should be the default 12h. When measuring 45nm Intel CPUs, the Ideality Setting should be 15h.

4.8 Product ID Register (EDh)

Table 4.10 Product ID Register

| ADDR | REGISTER | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | DEFAULT |
|------|----------|----|----|----|----|----|----|----|----|--|
| EDh | PID | 0 | 0 | 1 | 1 | 0 | 0 | X | X | 30h (-1) 31h (-2) 32h (-3) 33h (-4) |

The Product ID Register holds the unique product ID for identifying SMSC EMC products. See [Table 4.1](#) for a list of the product ID number for each version of the EMC1063.

4.9 Manufacturer ID Register (FEh)

Table 4.11 Manufacturer ID Register

| ADDR | REGISTER | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | DEFAULT |
|------|----------|----|----|----|----|----|----|----|----|---------|
| FEh | SMSC | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 5Dh |

The Manufacturer ID register contains an 8 bit word that identifies the manufacturer of the EMC1063 (SMSC = 5Dh).

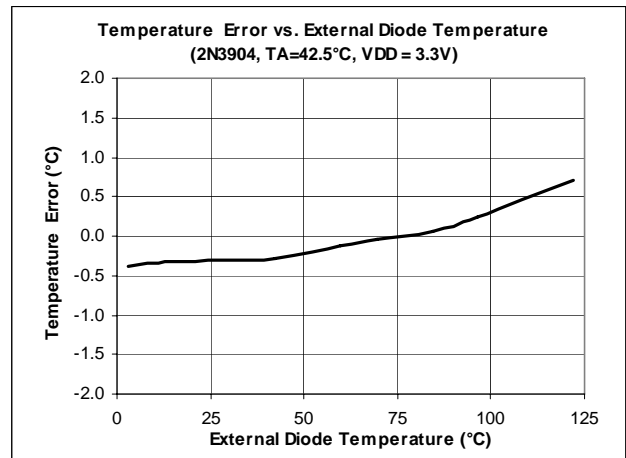
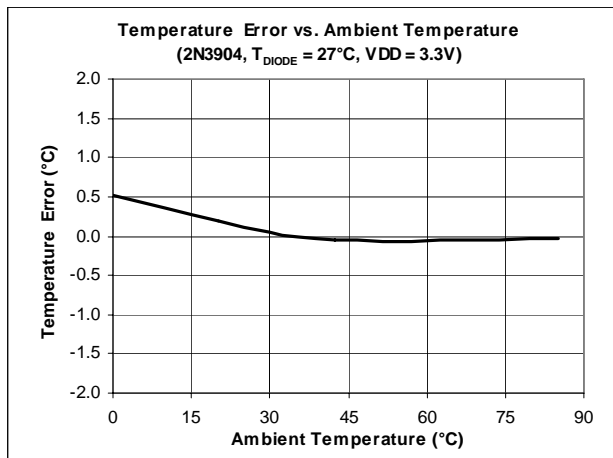
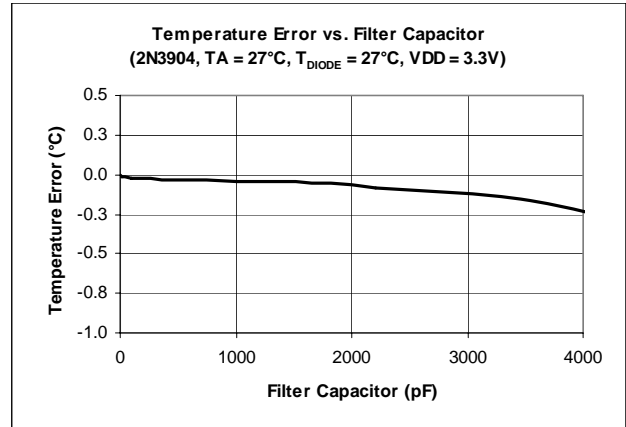
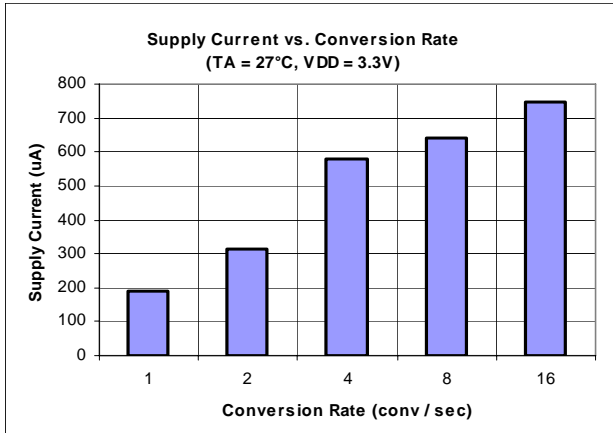
4.10 Revision Register (FFh)

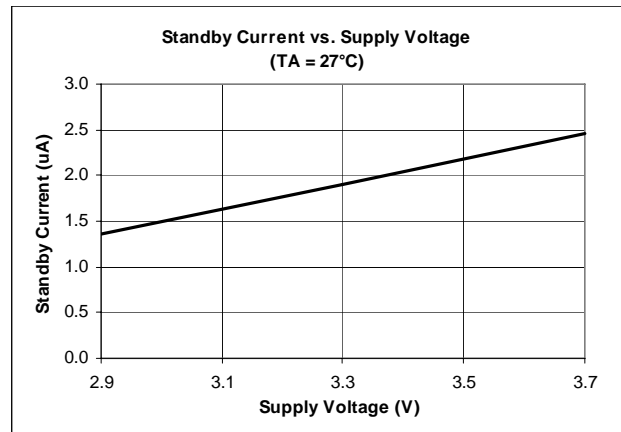
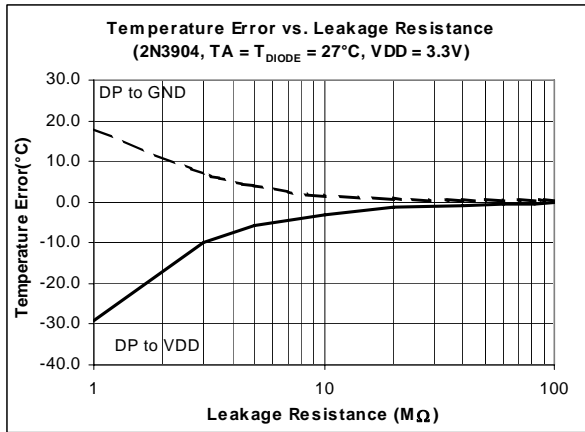
Table 4.12 Revision Register

| ADDR | REGISTER | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | DEFAULT |
|------|----------|----|----|----|----|----|----|----|----|---------|
| FFh | REV | - | - | - | - | 0 | 0 | 0 | 1 | 01h |

The Revision register contains a 4 bit word that identifies the die revision.

Chapter 5 Typical Operating Curves





Chapter 6 Package Outline

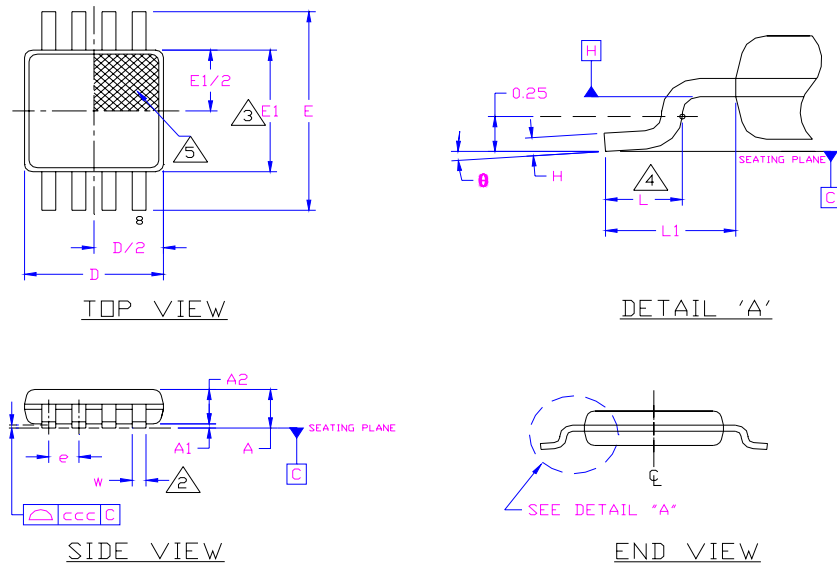


Figure 6.1 8-Pin MSOP Package Outline - 3x3mm Body 0.65mm Pitch

Table 6.1 8-Pin MSOP Package Parameters

| | MIN | NOMINAL | MAX | REMARKS |
|----------|----------|---------|------|------------------------|
| A | 0.80 | ~ | 1.10 | Overall Package Height |
| A1 | 0.05 | ~ | 0.15 | Standoff |
| A2 | 0.75 | 0.85 | 0.95 | Body Thickness |
| D | 2.80 | 3.00 | 3.20 | X Body Size |
| E | 4.65 | 4.90 | 5.15 | Y Span |
| E1 | 2.80 | ~ | 3.20 | Y body Size |
| H | 0.08 | ~ | 0.23 | Lead Foot Thickness |
| L | 0.40 | ~ | 0.80 | Lead Foot Length |
| L1 | 0.95 REF | | | Lead Length |
| e | 0.65 BSC | | | Lead Pitch |
| θ | 0° | ~ | 8° | Lead Foot Angle |
| W | 0.22 | ~ | 0.38 | Lead Width |
| ccc | ~ | ~ | 0.10 | Coplanarity |

Notes:

1. Controlling Unit: millimeters.
2. Tolerance on the true position of the leads is ± 0.065 mm maximum.
3. Package body dimensions D and E1 do not include mold protrusion or flash. Dimensions D and E1 to be determined at datum plane H. Maximum mold protrusion or flash is 0.15mm (0.006 inches) per end, and 0.15mm (0.006 inches) per side.
4. Dimension for foot length L measured at the gauge plane 0.25 mm above the seating plane.
5. Details of pin 1 identifier are optional but must be located within the zone indicated.

6.1 Package Markings

All devices will be marked on the first line of the top side with "1063". On the second line, they will be marked with the appropriate -X number (-1, -2, etc), the Functional Revision "B" and Country Code (CC) .