EMC1403/EMC1404

1°C Temperature Sensor with Beta Compensation

PRODUCT FEATURES

Datasheet

General Description

The EMC1403 and EMC1404 are high accuracy, low cost, System Management Bus (SMBus) temperature sensors. Advanced features such as Resistance Error Correction (REC), Beta Compensation (to support CPU diodes requiring the BJT/transistor model including 45nm, 65nm and 90nm processors) and automatic diode type detection combine to provide a robust solution for complex environmental monitoring applications.

Each device provides ±1° accuracy for external diode temperatures and ±2°C accuracy for the internal diode temperature. The EMC1403 monitors three temperature channels (two external and one internal). The EMC1404 monitors four temperature channels (three external and one internal).

Resistance Error Correction automatically eliminates the temperature error caused by series resistance allowing greater flexibility in routing thermal diodes. Beta Compensation eliminates temperature errors caused by low, variable beta transistors common in today's fine geometry processors. The automatic beta detection feature monitors each external diode/transistor and determines the optimum sensor settings for accurate temperature measurements regardless of processor technology. This frees the user from providing unique sensor configurations for each temperature monitoring application. These advanced features plus ±1°C measurement accuracy provide a low-cost, highly flexible and accurate solution for critical temperature monitoring applications.

Applications

- Notebook Computers
- Desktop Computers
- Industrial
- Embedded applications

Features

- Support for diodes requiring the BJT/transistor model
  - supports 45nm, 65nm, and 90nm CPU thermal diodes.
- Automatically determines external diode type and optimal settings
- Resistance Error Correction
- External Temperature Monitors
  - ±1°C Accuracy (60°C < T_{DIODE} < 100°C)
  - 0.125°C Resolution
  - Anti-parallel diodes for extra diode support
- Internal Temperature Monitor
  - ±2°C accuracy
- 3.3V Supply Voltage
- Programmable temperature limits for $\overline{\text{ALERT}}$ and $\overline{\text{THERM}}$
- Available in these Lead-free RoHS Compliant Packages
  - 10-pin 3mm x 3mm DFN
  - 10-pin MSOP
  - 14-pin SOIC

Ordering Information:

EMC1403-1-AIZL-TR for 10-pin, MSOP Lead-Free RoHS Compliant Package

EMC1403-2-AIZL-TR for 10-pin, MSOP Lead-Free RoHS Compliant Package

EMC1403-3-AIZL-TR for 10-pin, MSOP Lead-Free RoHS Compliant Package

EMC1403-4-AIZL-TR for 10-pin, MSOP Lead-Free RoHS Compliant Package

EMC1403-1-AIA-TR for 10-pin, DFN Lead-Free RoHS Compliant Package

EMC1403-2-AIA-TR for 10-pin, DFN Lead-Free RoHS Compliant Package

EMC1403-3-AIA-TR for 10-pin, DFN Lead-Free RoHS Compliant Package

EMC1403-4-AIA-TR for 10-pin, DFN Lead-Free RoHS Compliant Package

EMC1403-1-YZT-TR for 14-pin, SOIC Lead-Free RoHS Compliant Package

EMC1403-2-YZt-TR for 14-pin, SOIC Lead-Free RoHS Compliant Package

EMC1403-3-YZt-TR for 14-pin, SOIC Lead-Free RoHS Compliant Package

EMC1403-4-YZt-TR for 14-pin, SOIC Lead-Free RoHS Compliant Package

EMC1404-1-AIZL-TR for 10-pin, MSOP Lead-Free RoHS Compliant Package

EMC1404-2-AIZL-TR for 10-pin, MSOP Lead-Free RoHS Compliant Package

EMC1404-3-AIZL-TR for 10-pin, MSOP Lead-Free RoHS Compliant Package

EMC1404-4-AIZL-TR for 10-pin, MSOP Lead-Free RoHS Compliant Package

Note: See Table 1.1, "Part Selection" for SMBus addressing options.

REEL SIZE IS 4,000 PIECES.

This product meets the halogen maximum concentration values per IEC61249-2-21

For RoHS compliance and environmental information, please visit www.smsc.com/rohs

Please contact your SMSC sales representative for additional documentation related to this product such as application notes, anomaly sheets, and design guidelines.

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Chapter 1 Block Diagram

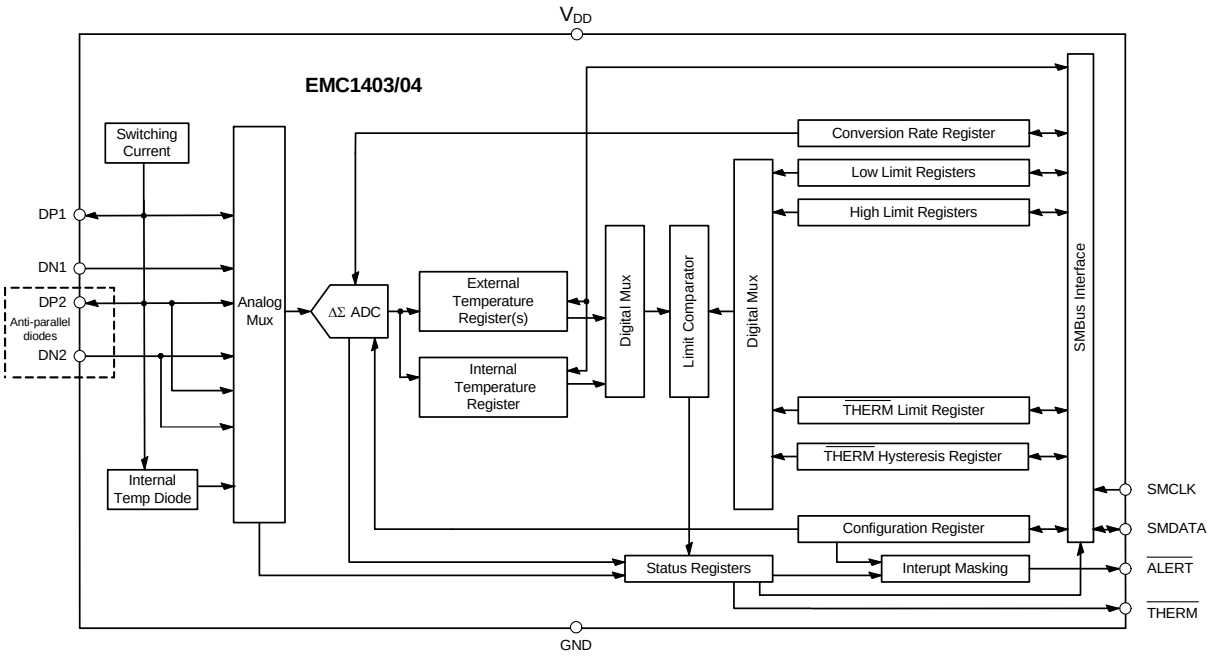

Figure 1.1 EMC1403/EMC1404 Block Diagram

1.1 Part Selection

The EMC1403 and EMC1404 device configuration is highlighted below.

Table 1.1 Part Selection

PART NUMBER	SMBUS ADDRESS	FUNCTIONALITY				PRODUCT ID
		EXTERNAL DIODES	DIODE 1 DEFAULT CONFIGURATION	DIODE 2 DEFAULT CONFIGURATION	OTHER	
EMC1403 - 1 - AIZL	1001_100xb	2	Detect Diode w/ REC enabled	Detect Diode w/ REC enabled	Software program-mable and mask-able High Limits Software program-mable THERM Limits	21h
EMC1403 - 2 - AIZL	1001_101xb					
EMC1403 - 3 - AIZL	0011_000xb					
EMC1403 - 4 - AIZL	0101_001xb					

Table 1.1 Part Selection (continued)

PART NUMBER	SMBUS ADDRESS	FUNCTIONALITY				PRODUCT ID
		EXTERNAL DIODES	DIODE 1 DEFAULT CONFIGURATION	DIODE 2 DEFAULT CONFIGURATION	OTHER	
EMC1403 - 1 - AIA	1001_100xb	2	Detect Diode w/ REC enabled	Detect Diode w/ REC enabled	Software programmable and maskable High Limits Software programmable THERM Limits	21h
EMC1403 - 2 - AIA	1001_101xb					
EMC1403 - 3 - AIA	0011_000xb					
EMC1403 - 4 - AIA	0101_001xb					
EMC1403 - 1 - YZT	1001_100xb	2	Detect Diode w/ REC enabled	Detect Diode w/ REC enabled	Software programmable and maskable High Limits Software programmable THERM Limits	21h
EMC1403 - 2 - YZT	1001_101xb					
EMC1403 - 3 - YZT	0011_000xb					
EMC1403 - 4 - YZT	0101_001xb					
EMC1404 - 1	1001_100xb	3	Detect Diode w/ REC enabled	Fixed 2N3904 in anti-parallel diode configuration Note 1.1	Software programmable and maskable High Limits Software programmable THERM Limits	25h
EMC1404 - 2	1001_101xb					
EMC1404 - 3	0011_000xb					
EMC1404 - 4	0101_001xb					

Note 1.1 External 2 and external 3 channels have beta configuration hard wired to ‘0111b’ and REC enabled.

Chapter 2 Pin Description

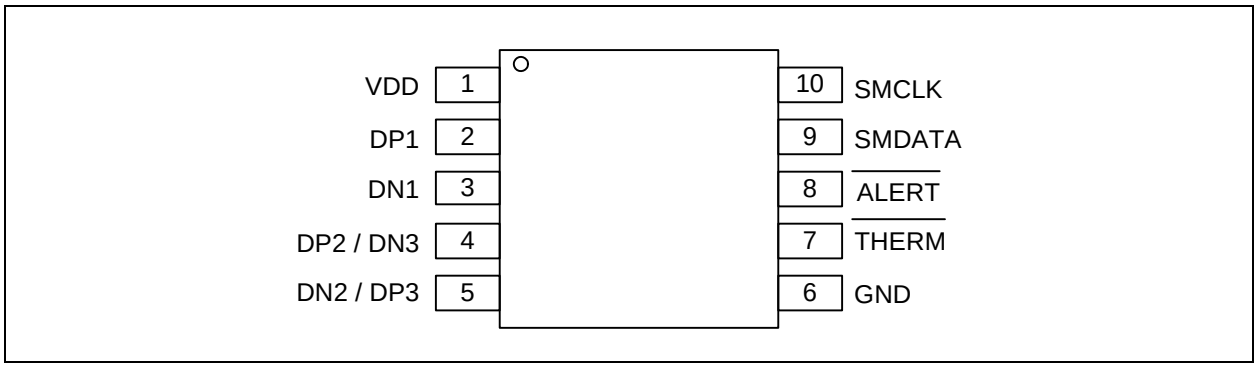

Figure 2.1 EMC1403/EMC1404 Pin Diagram, MSOP-10

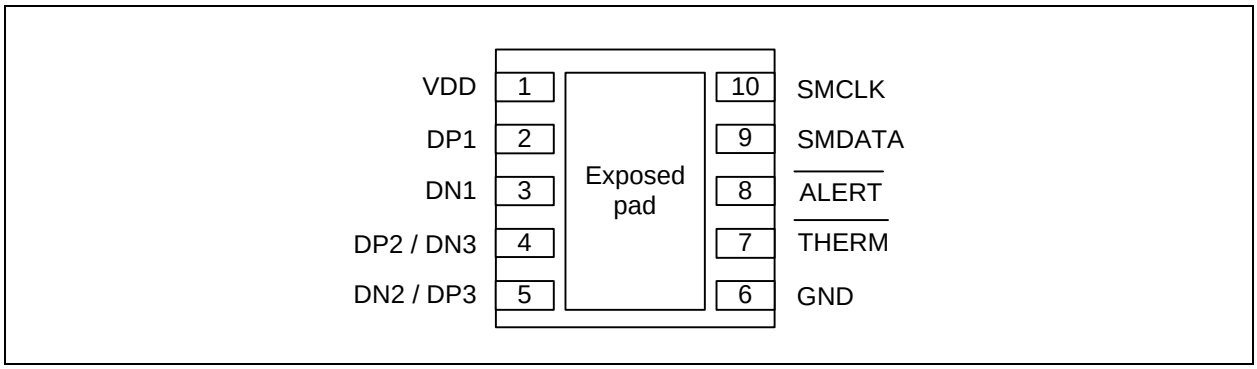

Figure 2.2 EMC1403/EMC1404 Pin Diagram, DFN-10

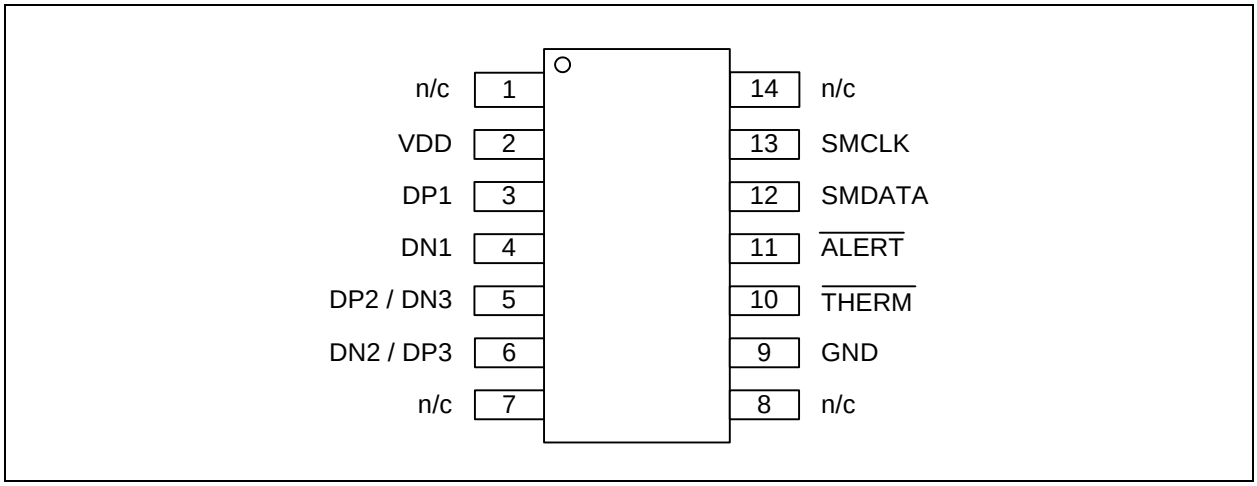

Figure 2.3 EMC1403/EMC1404 Pin Diagram, SOIC-14

Table 2.1 EMC1403 and EMC1404 Pin Description

PIN NUMBER 10-PIN	PIN NUMBER 14-PIN	NAME	FUNCTION	TYPE
n/a	1	n/c	Not Internally Connected	n/a
1	2	VDD	Power supply	Power
2	3	DP1	External diode 1 positive (anode) connection	AIO
3	4	DN1	External diode 1 negative (cathode) connection	AIO
4	5	DP2 / DN3	External diode 2 positive (anode) connection / External Diode 3 negative (cathode) connection for anti-parallel diodes	AIO
5	6	DN2 / DP3	External diode 2 negative (cathode) connection / External Diode 3 positive (anode) connection for anti-parallel diodes	AIO
n/a	7	n/c	Not Internally Connected	n/a
n/a	8	n/c	Not Internally Connected	n/a
6	9	GND	Ground	Power
7	10	$\overline{\text{THERM}}$	Critical $\overline{\text{THERM}}$ output signal - requires pull-up resistor	OD (5V)
8	11	$\overline{\text{ALERT}}$	Active low digital $\overline{\text{ALERT}}$ output signal - requires pull-up resistor	OD (5V)
9	12	SMDATA	SMBus Data input/output - requires pull-up resistor	DIOD (5V)
10	13	SMCLK	SMBus Clock input - requires pull-up resistor	DI (5V)
n/a	14	n/c	Not Internally Connected	n/a
DFN Bottom Pad	n/a	Exposed Pad	Not Internally Connected, recommend grounding.	n/a

APPLICATION NOTE: For the 5V tolerant pins that have a pull-up resistor (SMCLK, SMDATA, $\overline{\text{THERM}}$, and $\overline{\text{ALERT}}$), the voltage difference between VDD and the pull-up voltage must never exceed 3.6V.

The pin types are described below:

Power - these pins are used to supply either VDD or GND to the device.

AIO - Analog Input / Output.

DI - Digital Input.

OD - Open Drain Digital Output.

DIOD - Digital Input / Open Drain Output.

Chapter 3 Electrical Specifications

3.1 Absolute Maximum Ratings

Table 3.1 Absolute Maximum Ratings

DESCRIPTION	RATING	UNIT
Supply Voltage (V_{DD})	-0.3 to 4.0	V
Voltage on 5V tolerant pins (V_{5VT_pin})	-0.3 to 5.5	V
Voltage on 5V tolerant pins ($\|V_{5VT_pin} - V_{DD}\|$) (see Note 3.1)	-0.3 to 3.6	V
Voltage on any other pin to Ground	-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-10		
Thermal Resistance (θ_{j-a})	132.2	°C/W
Package Thermal Characteristics for SOIC-14		
Thermal Resistance (θ_{j-a})	77.7	°C/W
Package Thermal Characteristics for DFN-10		
Thermal Resistance (θ_{j-a})	77.1	°C/W
ESD Rating, All pins HBM	2000	V

Note: Stresses at or above those listed could cause permanent 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.

Note 3.1 For the 5V tolerant pins that have a pull-up resistor (SMCLK, SMDATA, $\overline{\text{THERM}}$, and $\overline{\text{ALERT}}$), the pull-up voltage must not exceed 3.6V when the device is unpowered.

3.2 Electrical Specifications

Table 3.2 Electrical Specifications

V_{DD} = 3.0V to 3.6V, T_A = -40°C to 125°C, all typical values at T_A = 27°C unless otherwise noted.						
CHARACTERISTIC	**SYMBOL**	**MIN**	**TYP**	**MAX**	**UNITS**	**CONDITIONS**
DC Power						
Supply Voltage	V_{DD}	3.0	3.3	3.6	V	
Supply Current	I_{DD}		430	850	uA	1 conversion / sec, dynamic averaging disabled
			930	1200	uA	4 conversions / sec, dynamic averaging enabled
			1120		uA	≥ 16 conversions / sec, dynamic averaging enabled
Standby Supply Current	I_{DD}		170	230	uA	Device in Standby mode, no SMBus communications, ALERT and THERM pins not asserted.
Internal Temperature Monitor						
Temperature Accuracy			±0.25	±1	°C	-5°C < T_A < 100°C
				±2	°C	-40°C < T_A < 125°C
Temperature Resolution			0.125		°C	
External Temperature Monitor						
Temperature Accuracy			±0.25	±1	°C	+20°C < T_{DIODE} < +110°C 0°C < T_A < 100°C
			±0.5	±2	°C	-40°C < T_{DIODE} < 127°C
Temperature Resolution			0.125		°C	
	t_{CONV}		190		ms	EMC1403, default settings
	t_{CONV}		150		ms	EMC1404, default settings
Capacitive Filter	C_{FILTER}		2.2	2.5	nF	Connected across external diode
$\overline{\text{ALERT}}$ and $\overline{\text{THERM}}$ pins						
Output Low Voltage	V_{OL}	0.4			V	I_{SINK} = 8mA
Leakage Current	I_{LEAK}			±5	uA	$\overline{\text{ALERT}}$ and $\overline{\text{THERM}}$ pins Device powered or unpowered T_A < 85°C pull-up voltage ≤ 3.6V

3.3 SMBus Electrical Characteristics

Table 3.3 SMBus Electrical Specifications

V_{DD} = 3.0V to 3.6V, T_A = -40°C to 125°C, all typical values are at T_A = 27°C unless otherwise noted.						
CHARACTERISTIC	**SYMBOL**	**MIN**	**TYP**	**MAX**	**UNITS**	**CONDITIONS**
SMBus Interface						
Input High Voltage	V_{IH}	2.0		V_{DD}	V	5V Tolerant
Input Low Voltage	V_{IL}	-0.3		0.8	V	5V Tolerant
Input High/Low Current	I_{IH} / I_{IL}			±5	uA	Powered or unpowered TA < 85°C
Hysteresis			420		mV	
Input Capacitance	C_{IN}		5		pF	
Output Low Sink Current	I_{OL}	8.2		15	mA	SMDATA = 0.4V
SMBus Timing						
Clock Frequency	f_{SMB}	10		400	kHz	
Spike Suppression	t_{SP}			50	ns	
Bus free time Start to Stop	t_{BUF}	1.3			us	
Hold Time: Start	$t_{HD:STA}$	0.6			us	
Setup Time: Start	$t_{SU:STA}$	0.6			us	
Setup Time: Stop	$t_{SU:STP}$	0.6			us	
Data Hold Time	$t_{HD:DAT}$	0			us	When transmitting to the master
Data Hold Time	$t_{HD:DAT}$	0.3			us	When receiving from the master
Data Setup Time	$t_{SU:DAT}$	100			ns	
Clock Low Period	t_{LOW}	1.3			us	
Clock High Period	t_{HIGH}	0.6			us	
Clock/Data Fall time	t_{FALL}			300	ns	Min = 20+0.1C_{LOAD} ns
Clock/Data Rise time	t_{RISE}			300	ns	Min = 20+0.1C_{LOAD} ns
Capacitive Load	C_{LOAD}			400	pF	per bus line

Chapter 4 System Management Bus Interface Protocol

4.1 System Management Bus Interface Protocol

The EMC1403 and EMC1404 communicate with a host controller, such as an SMSC SIO, through the SMBus. The SMBus is a two-wire serial communication protocol between a computer host and its peripheral devices. A detailed timing diagram is shown in Figure 4.1.

For the first 15ms after power-up the device may not respond to SMBus communications.

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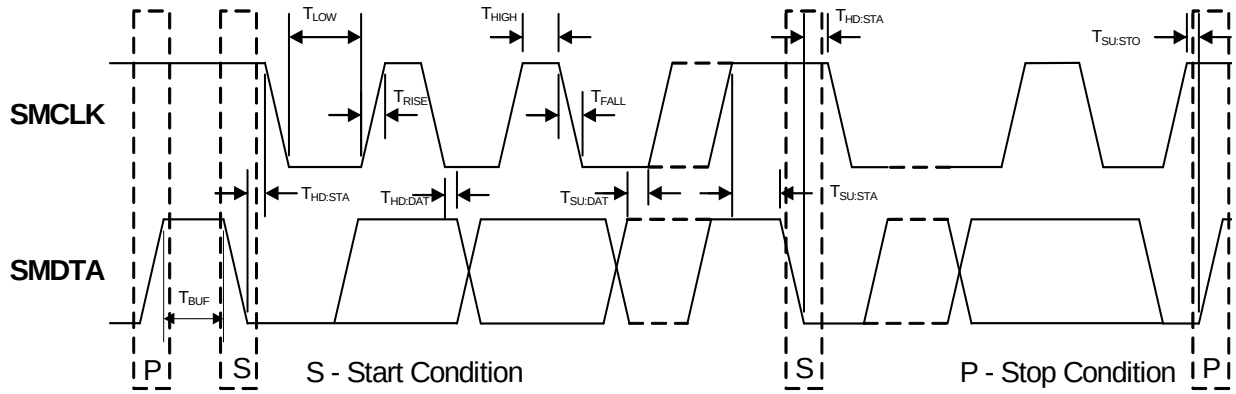


Figure 4.1 SMBus Timing Diagram

The EMC1403 and EMC1404 are SMBus 2.0 compatible and support Send Byte, Read Byte, Write Byte, Receive Byte, and the Alert Response Address as valid protocols as shown below.

All of the below protocols use the convention in Table 4.1.

Table 4.1 Protocol Format

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

Attempting to communicate with the EMC1403 and EMC1404 SMBus interface with an invalid slave address or invalid protocol will result in no response from the device and will not affect its register contents. Stretching of the SMCLK signal is supported, provided other devices on the SMBus control the timing.

4.2 Write Byte

The Write Byte is used to write one byte of data to the registers as shown below Table 4.2:

Table 4.2 Write Byte Protocol

START	SLAVE ADDRESS	WR	ACK	REGISTER ADDRESS	ACK	REGISTER DATA	ACK	STOP
1 -> 0	1001_100	0	0	XXh	0	XXh	0	0 -> 1

4.3 Read Byte

The Read Byte protocol is used to read one byte of data from the registers as shown in Table 4.3.

Table 4.3 Read Byte Protocol

START	SLAVE ADDRESS	WR	ACK	REGISTER ADDRESS	ACK	START	SLAVE ADDRESS	RD	ACK	REGISTER DATA	NACK	STOP
1 -> 0	1001_100	0	1	XXh	0	1 -> 0	1001_100	1	1	XX	1	0 -> 1

4.4 Send Byte

The Send Byte protocol is used to set the internal address register pointer to the correct address location. No data is transferred during the Send Byte protocol as shown in Table 4.4.

Table 4.4 Send Byte Protocol

START	SLAVE ADDRESS	WR	ACK	REGISTER ADDRESS	ACK	STOP
1 -> 0	1001_100	0	0	XXh	0	0 -> 1

4.5 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 is used for consecutive reads of the same register as shown in Table 4.5.

Table 4.5 Receive Byte Protocol

START	SLAVE ADDRESS	RD	ACK	REGISTER DATA	NACK	STOP
1 -> 0	1001_100	1	0	XXh	1	0 -> 1

4.6 Alert Response Address

The $\overline{\text{ALERT}}$ output can be used as a processor interrupt or as an SMBus Alert.

When it detects that the $\overline{\text{ALERT}}$ pin is asserted, the host will send the Alert Response Address (ARA) to the general address of 0001_100xb. All devices with active interrupts will respond with their client address as shown in Table 4.6.

Table 4.6 Alert Response Address Protocol

START	ALERT RESPONSE ADDRESS	RD	ACK	DEVICE ADDRESS	NACK	STOP
1 -> 0	0001_100	1	0	1001_1000	1	0 -> 1

The EMC1403 and EMC1404 will respond to the ARA in the following way:

1. Send Slave Address and verify that full slave address was sent (i.e. the SMBus communication from the device was not prematurely stopped due to a bus contention event).
2. Set the MASK bit to clear the $\overline{\text{ALERT}}$ pin.

APPLICATION NOTE: The ARA does not clear the Status Register and if the MASK bit is cleared prior to the Status Register being cleared, the $\overline{\text{ALERT}}$ pin will be reasserted.

4.7 SMBus Address

The EMC1403 and EMC1404 respond to hard-wired SMBus slave address as shown in Table 1.1.

Note: Other addresses are available. Contact SMSC for more information.

4.8 SMBus Timeout

The EMC1403 and EMC1404 support SMBus Timeout. If the clock line is held low for longer than 30ms, the device will reset its SMBus protocol. This function can be enabled by setting the TIMEOUT bit in the Consecutive Alert Register (see Section 6.12).

Chapter 5 Product Description

The EMC1403 and EMC1404 are SMBus temperature sensors. The EMC1403 monitors one internal diode and two externally connected temperature diodes. The EMC1404 monitors one internal diode and three externally connected temperature diodes.

Thermal management is performed in cooperation with a host device. This consists of the host reading the temperature data of both the external and internal temperature diodes of the EMC1403 and EMC1404 and using that data to control the speed of one or more fans.

The EMC1403 and EMC1404 have two levels of monitoring. The first provides a maskable $\overline{\text{ALERT}}$ signal to the host when the measured temperatures exceeds user programmable limits. This allows the EMC1403 or EMC1404 to be used as an independent thermal watchdog to warn the host of temperature hot spots without direct control by the host. The second level of monitoring provides a non maskable interrupt on the $\overline{\text{THERM}}$ pin if the measured temperatures meet or exceed a second programmable limit.

Since the EMC1403 and EMC1404 automatically correct for temperature errors due to series resistance in temperature diode lines, there is greater flexibility in where external diodes are positioned and better measurement accuracy than previously available with non-resistance error correcting devices. The automatic beta detection feature means that there is no need to program the device according to which type of diode is present on the External Diode 1 channel. This also includes CPU diodes that require the transistor or BJT model for monitoring their temperature. Therefore, the EMC1403/EMC1404 can power up ready to operate for any system configuration.

For the EMC1404, External Diode channels 2 and 3 are only compatible with general purpose diodes (such as a 2N3904).

Figure 5.1 shows a system level block diagram of the EMC1403. Figure 5.2 shows a system level block diagram of the EMC1404.

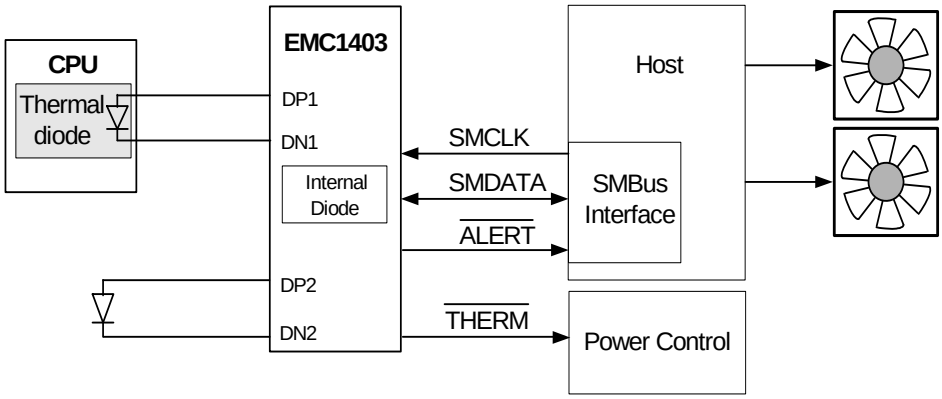


Figure 5.1 System Diagram for EMC1403

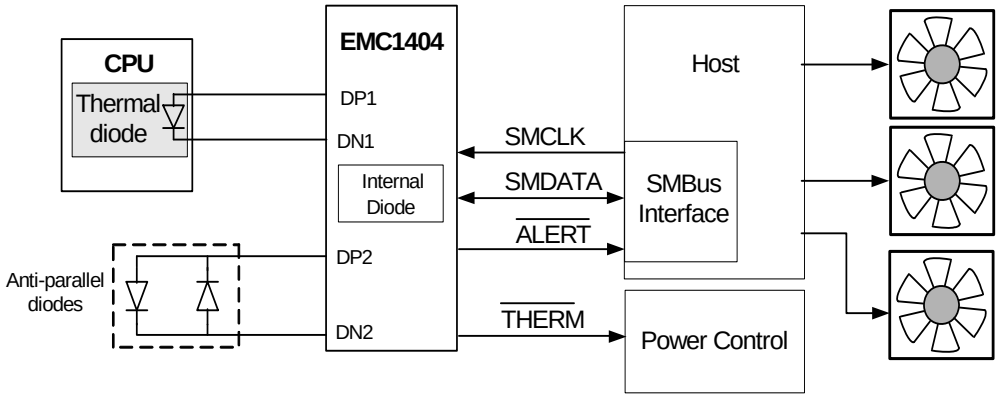


Figure 5.2 System Diagram for EMC1404

5.1 Modes of Operation

The EMC1403 and EMC1404 have two modes of operation.

- Active (Run) - In this mode of operation, the ADC is converting on all temperature channels at the programmed conversion rate. The temperature data is updated at the end of every conversion and the limits are checked. In Active mode, writing to the one-shot register will do nothing.
- Standby (Stop) - In this mode of operation, the majority of circuitry is powered down to reduce supply current. The temperature data is not updated and the limits are not checked. In this mode of operation, the SMBus is fully active and the part will return requested data. Writing to the one-shot register will enable the device to update all temperature channels. Once all the channels are updated, the device will return to the Standby mode.

5.1.1 Conversion Rates

The EMC1403 and EMC1404 may be configured for different conversion rates based on the system requirements. The conversion rate is configured as described in Section 6.5. The default conversion rate is 4 conversions per second. Other available conversion rates are shown in Table 6.6.

5.1.2 Dynamic Averaging

Dynamic averaging causes the EMC1403 and EMC1404 to measure the external diode channels for an extended time based on the selected conversion rate. This functionality can be disabled for increased power savings at the lower conversion rates (see Section 6.4). When dynamic averaging is enabled, the device will automatically adjust the sampling and measurement time for the external diode channels. This allows the device to average 2x or 16x longer than the normal 11 bit operation (nominally 21ms per channel) 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 of the temperature measurement.

When enabled, 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.

When enabled, the dynamic averaging will affect the average supply current based on the chosen conversion rate as shown in Table 5.1 for EMC1403.

Table 5.1 Supply Current vs. Conversion Rate for EMC1403

CONVERSION RATE	AVERAGE SUPPLY CURRENT		AVERAGING FACTOR (BASED ON 11-BIT OPERATION)	
	ENABLED (DEFAULT)	DISABLED	ENABLED (DEFAULT)	DISABLED
1 / 16 sec	660uA	430uA	16x	1x
1 / 8 sec	660uA	430uA	16x	1x
1 / 4 sec	660uA	430uA	16x	1x
1 / 2 sec	660uA	430uA	16x	1x
1 / sec	660uA	430uA	16x	1x
2 / sec	930uA	475uA	8x	1x
4 / sec (default)	950uA	510uA	4x	1x
8 / sec	1010uA	630uA	2x	1x
16 / sec	1020uA	775uA	1x	1x
32 / sec	1050uA	1050uA	0.5x	0.5x
64 / sec	1100uA	1100uA	0.25x	0.25x

When enabled, the dynamic averaging will affect the average supply current based on the chosen conversion rate as shown in Table 5.2 for EMC1404.

Table 5.2 Supply Current vs. Conversion Rate for EMC1404

CONVERSION RATE	AVERAGE SUPPLY CURRENT		AVERAGING FACTOR (BASED ON 11-BIT OPERATION)	
	ENABLED (DEFAULT)	DISABLED	ENABLED (DEFAULT)	DISABLED
1 / 16 sec	660uA	430uA	16x	1x
1 / 8 sec	660uA	430uA	16x	1x
1 / 4 sec	660uA	430uA	16x	1x
1 / 2 sec	660uA	430uA	16x	1x
1 / sec	660uA	430uA	8x	1x
2 / sec	930uA	475uA	4x	1x
4 / sec (default)	950uA	510uA	2x	1x
8 / sec	1010uA	630uA	1x	1x
16 / sec	1020uA	775uA	0.5x	0.5x

Table 5.2 Supply Current vs. Conversion Rate for EMC1404 (continued)

CONVERSION RATE	AVERAGE SUPPLY CURRENT		AVERAGING FACTOR (BASED ON 11-BIT OPERATION)	
	ENABLED (DEFAULT)	DISABLED	ENABLED (DEFAULT)	DISABLED
32 / sec	1050uA	1050uA	0.25x	0.25x
64 / sec	1100uA	1100uA	0.125x	0.125x

5.2 THERM Output

The THERM output is asserted independently of the ALERT output and cannot be masked. Whenever any of the measured temperatures exceed the user programmed THERM Limit values for the programmed number of consecutive measurements, the THERM output is asserted. Once it has been asserted, it will remain asserted until all measured temperatures drop below the THERM Limit minus the THERM Hysteresis (also programmable).

When the THERM pin is asserted, the Therm status bits will likewise be set. Reading these bits will not clear them until the THERM pin is deasserted. Once the THERM pin is deasserted, the THERM status bits will be automatically cleared.

5.3 ALERT Output

The ALERT pin is an open drain output and requires a pull-up resistor to V_{DD} and has two modes of operation: interrupt mode and comparator Mode. The mode of the ALERT output is selected via the ALERT / COMP bit in the Configuration Register (see Section 6.4).

5.3.1 ALERT Pin Interrupt Mode

When configured to operate in interrupt mode, the ALERT pin asserts low when an out of limit measurement (≥ high limit or < low limit) is detected on any diode or when a diode fault is detected. The ALERT pin will remain asserted as long as an out-of-limit condition remains. Once the out-of-limit condition has been removed, the ALERT pin will remain asserted until the appropriate status bits are cleared.

The ALERT pin can be masked by setting the MASK bit. Once the ALERT pin has been masked, it will be de-asserted and remain de-asserted until the MASK bit is cleared by the user. Any interrupt conditions that occur while the ALERT pin is masked will update the Status Register normally.

The ALERT pin is used as an interrupt signal or as an Smbus Alert signal that allows an SMBus slave to communicate an error condition to the master. One or more ALERT outputs can be hard-wired together.

5.3.2 ALERT Pin Comparator Mode

When the ALERT pin is configured to operate in comparator mode it will be asserted if any of the measured temperatures exceeds the respective high limit. The ALERT pin will remain asserted until all temperatures drop below the corresponding high limit minus the THERM Hysteresis value.

When the ALERT pin is asserted in comparator mode, the corresponding high limit status bits will be set. Reading these bits will not clear them until the ALERT pin is deasserted. Once the ALERT pin is deasserted, the status bits will be automatically cleared.

The MASK bit will not block the ALERT pin in this mode, however the individual channel masks (see Section 6.11) will prevent the respective channel from asserting the ALERT pin.

5.4 Beta Compensation

The EMC1403 and EMC1404 are configured to monitor the temperature of basic diodes (e.g. 2N3904), or CPU thermal diodes. It automatically detects the type of external diode (CPU diode or diode connected transistor) and determines the optimal setting to reduce temperature errors introduced by beta variation for the External Diode 1 channel only. Compensating for this error is also known as implementing the transistor or BJT model for temperature measurement.

For discrete transistors configured with the collector and base shorted together, the beta is generally sufficiently high such that the percent change in beta variation is very small. For example, a 10% variation in beta for two forced emitter currents with a transistor whose ideal beta is 50 would contribute approximately 0.25°C error at 100°C. However for substrate transistors where the base-emitter junction is used for temperature measurement and the collector is tied to the substrate, the proportional beta variation will cause large error. For example, a 10% variation in beta for two forced emitter currents with a transistor whose ideal beta is 0.5 would contribute approximately 8.25°C error at 100°C.

The External Diode 2 and External Diode 3 channels do not support Beta Compensation.

5.5 Resistance Error Correction (REC)

Parasitic resistance in series with the external diodes will limit the accuracy obtainable from temperature measurement devices. The voltage developed across this resistance by the switching diode currents cause the temperature measurement to read higher than the true temperature. Contributors to 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. Typically, the error caused by series resistance is +0.7°C per ohm. The EMC1403 and EMC1404 automatically correct up to 100 ohms of series resistance.

5.6 Programmable External Diode Ideality Factor

The EMC1403 and EMC1404 is designed for external diodes with an ideality factor of 1.008. Not all external diodes, processor or discrete, will have this exact value. This variation of the ideality factor introduces error in the temperature measurement which must be corrected for. This correction is typically done using programmable offset registers. Since an ideality factor mismatch introduces an error that is a function of temperature, this correction is only accurate within a small range of temperatures. To provide maximum flexibility to the user, the EMC1403 and EMC1404 provides a 6-bit register for each external diode where the ideality factor of the diode used is programmed to eliminate errors across all temperatures.

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.

5.7 Diode Faults

The EMC1403 and EMC1404 detect an open on the DP and DN pins, and a short across the DP and DN pins. For each temperature measurement made, the device checks for a diode fault on the external diode channel(s). When a diode fault is detected, the ALERT pin asserts (unless masked, see Section 5.8) and the temperature data reads 00h in the MSB and LSB registers (note: the low limit will not be checked). A diode fault is defined as one of the following: an open between DP and DN, a short from V_{DD} to DP, or a short from V_{DD} to DN.

If a short occurs across DP and DN or a short occurs from DP to GND, the low limit status bit is set and the ALERT pin asserts (unless masked). This condition is indistinguishable from a temperature measurement of 0.000degC (-64°C in extended range) resulting in temperature data of 00h in the MSB and LSB registers.

If a short from DN to GND occurs (with a diode connected), temperature measurements will continue as normal with no alerts.

5.8 Consecutive Alerts

The EMC1403 and EMC1404 contain multiple consecutive alert counters. One set of counters applies to the ALERT pin and the second set of counters applies to the THERM pin. Each temperature measurement channel has a separate consecutive alert counter for each of the ALERT and THERM pins. All counters are user programmable and determine the number of consecutive measurements that a temperature channel(s) must be out-of-limit or reporting a diode fault before the corresponding pin is asserted.

See Section 6.12 for more details on the consecutive alert function.

5.9 Digital Filter

To reduce the effect of noise and temperature spikes on the reported temperature, the External Diode 1 channel uses a programmable digital filter. This filter can be configured as Level 1, Level 2, or Disabled. The typical filter performance is shown in Figure 5.3 and Figure 5.4.

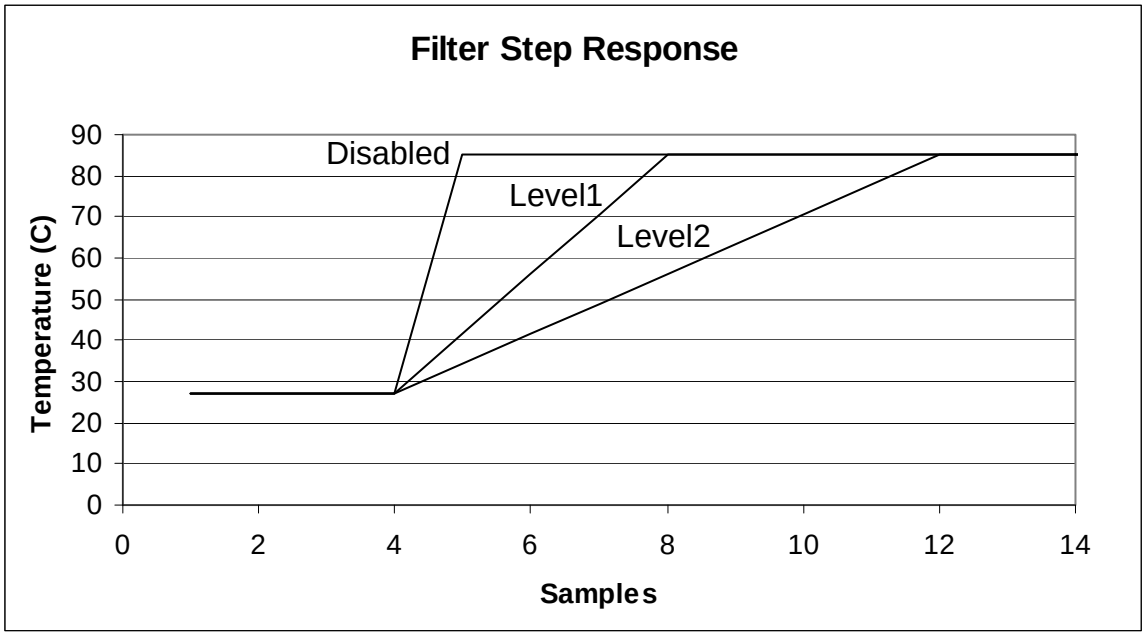


Figure 5.3 Temperature Filter Step Response

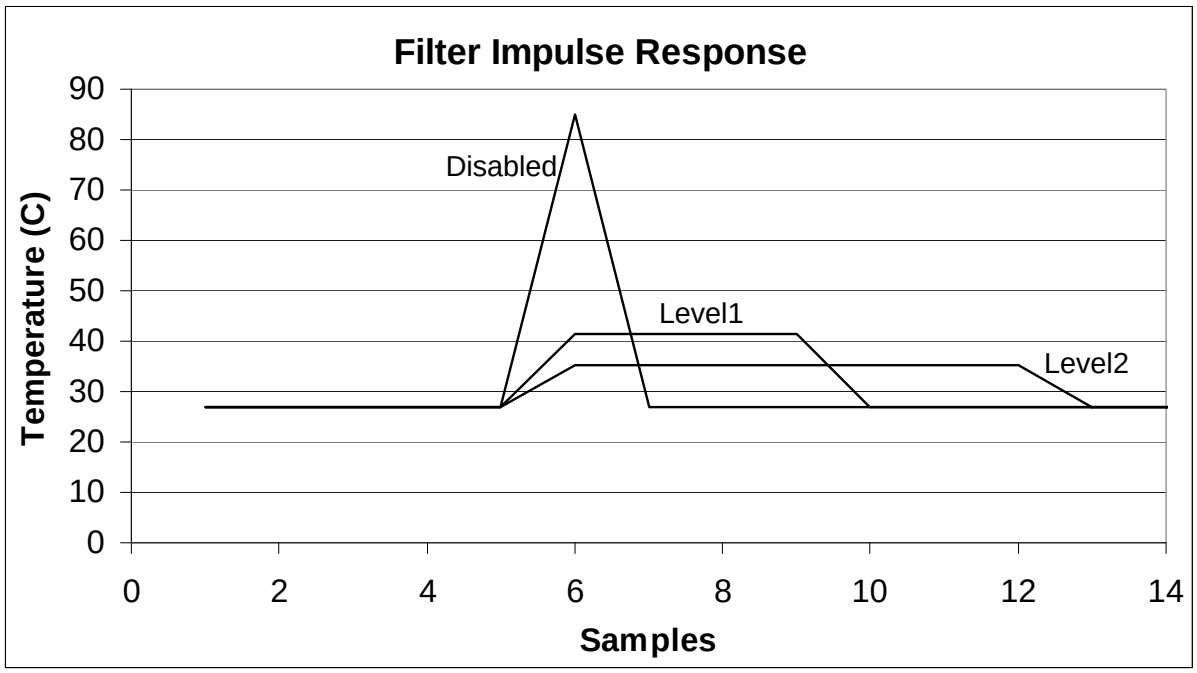


Figure 5.4 Temperature Filter Impulse Response

5.10 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 proportional to absolute temperature as shown in the following equation:

$$\Delta V_{BE} = \frac{\eta kT}{q} \ln\left(\frac{I_{HIGH}}{I_{LOW}}\right) \quad \textbf{[1]}$$

where:

k = Boltzmann's constant

T = absolute temperature in Kelvin

q = electron charge

η = diode ideality factor

Figure 5.5 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.

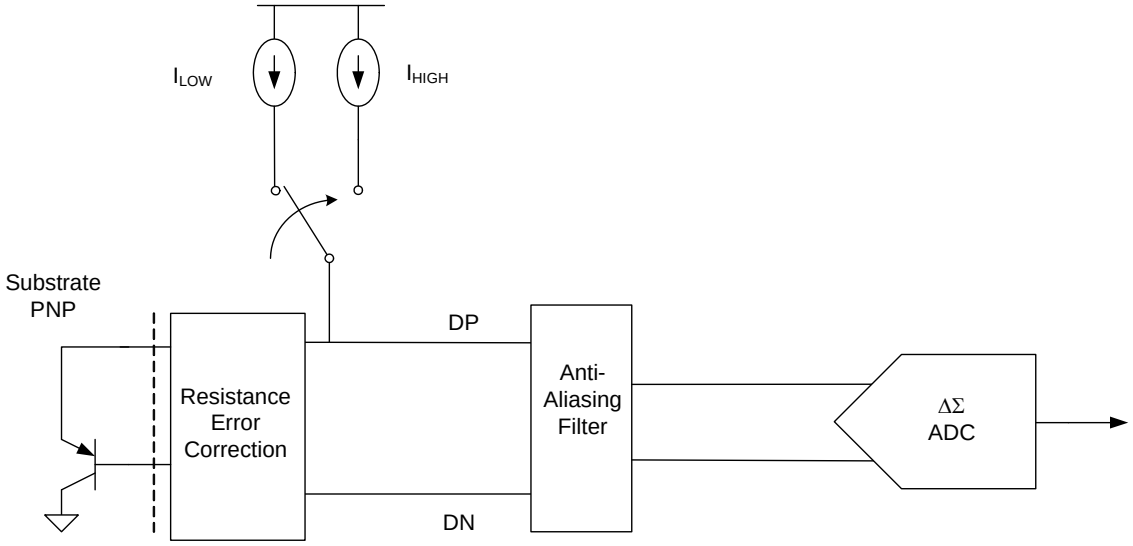


Figure 5.5 Block Diagram of Temperature Monitoring Circuit

5.11 Temperature Measurement Results and Data

The temperature measurement results are stored in the internal and external temperature registers. These are then compared with the values stored in the high and low limit registers. Both external and internal temperature measurements are stored in 11-bit format with the eight (8) most significant bits stored in a high byte register and the three (3) least significant bits stored in the three (3) MSB positions of the low byte register. All other bits of the low byte register are set to zero.

The EMC1403 and EMC1404 have two selectable temperature ranges. The default range is from 0°C to +127°C and the temperature is represented as binary number able to report a temperature from 0°C to +127.875°C in 0.125°C steps.

The extended range is an extended temperature range from -64°C to +191°C. The data format is a binary number offset by 64°C. The extended range is used to measure temperature diodes with a large known offset (such as AMD processor diodes) where the diode temperature plus the offset would be equivalent to a temperature higher than +127°C.

Table 5.3 shows the default and extended range formats.

Table 5.3 Temperature Data Format

TEMPERATURE (°C)	DEFAULT RANGE 0°C TO 127°C	EXTENDED RANGE -64°C TO 191°C
Diode Fault	000 0000 0000	000 0000 0000
-64	000 0000 0000	000 0000 0000 Note 5.2
-1	000 0000 0000	001 1111 1000
0	000 0000 0000 Note 5.1	010 0000 0000
0.125	000 0000 0001	010 0000 0001
1	000 0000 1000	010 0000 1000

Table 5.3 Temperature Data Format (continued)

TEMPERATURE (°C)	DEFAULT RANGE 0°C TO 127°C	EXTENDED RANGE -64°C TO 191°C
64	010 0000 0000	100 0000 0000
65	010 0000 1000	100 0000 1000
127	011 1111 1000	101 1111 1000
127.875	011 1111 1111	101 1111 1111
128	011 1111 1111 Note 5.3	110 0000 0000
190	011 1111 1111	111 1111 0000
191	011 1111 1111	111 1111 1000
>= 191.875	011 1111 1111	111 1111 1111 Note 5.4

Note 5.1 In default mode, all temperatures < 0°C will be reported as 0°C.

Note 5.2 In the extended range, all temperatures < -64°C will be reported as -64°C.

Note 5.3 For the default range, all temperatures > +127.875°C will be reported as +127.875°C.

Note 5.4 For the extended range, all temperatures > +191.875°C will be reported as +191.875°C.

5.12 Anti-parallel Diode Connections

The EMC1404 supports reading two external diodes on the same set of pins (DP2, DN2). These diodes are connected as shown in Figure 5.2. Due to the anti-parallel connection of these diodes, both diodes will be reverse biased by a V_{BE} voltage (approximately 0.7V). Because of this reverse bias, only discrete thermal diodes (such as a 2N3904) are recommended to be placed on these pins.

5.13 External Diode Connections

The EMC1403 can be configured to measure a CPU substrate transistor, a discrete 2N3904 thermal diode, or an AMD processor diode. The diodes can be connected in a variety of ways as indicated in Figure 5.6.

The EMC1404 can be configured to measure a CPU substrate transistor, a discrete 2N3904 thermal diode, or an AMD processor diode on the External Diode 1 channel only. The External Diode 2 and External Diode 3 channels are configured to measure a pair of discrete anti-parallel diodes (shared on pins DP2 and DN2). The supported configurations for the external diode channels are shown in Figure 5.6.

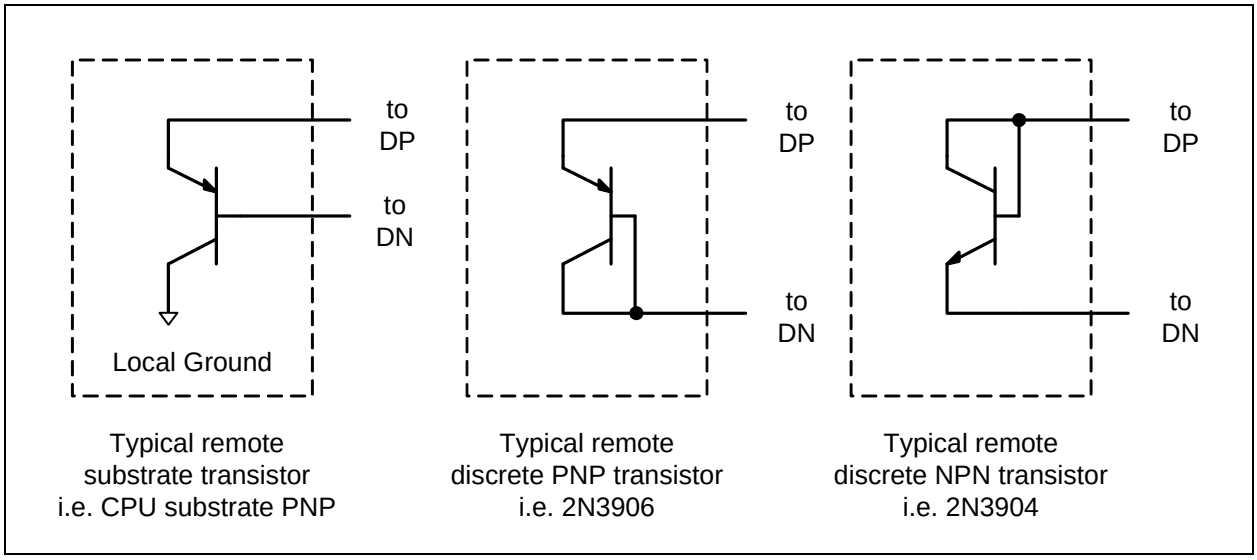


Figure 5.6 Diode Configurations

Chapter 6 Register Description

The registers shown in Table 6.1 are accessible through the SMBus. An entry of '-' indicates that the bit is not used and will always read '0'.

Table 6.1 Register Set in Hexadecimal Order

REGISTER ADDRESS	R/W	REGISTER NAME	FUNCTION	DEFAULT VALUE	PAGE
00h	R	Internal Diode Data High Byte	Stores the integer data for the Internal Diode	00h	Page 30
01h	R	External Diode 1 Data High Byte	Stores the integer data for External Diode 1	00h	
02h	R	Status	Stores the status bits for the Internal Diode and External Diodes	00h	Page 31
03h	R/W	Configuration	Controls the general operation of the device (mirrored at address 09h)	00h	Page 31
04h	R/W	Conversion Rate	Controls the conversion rate for updating temperature data (mirrored at address 0Ah)	06h (4/sec)	Page 32
05h	R/W	Internal Diode High Limit	Stores the 8-bit high limit for the Internal Diode (mirrored at address 0Bh)	55h (85°C)	Page 33
06h	R/W	Internal Diode Low Limit	Stores the 8-bit low limit for the Internal Diode (mirrored at address 0Ch)	00h (0°C)	
07h	R/W	External Diode 1 High Limit High Byte	Stores the integer portion of the high limit for External Diode 1 (mirrored at register 0Dh)	55h (85°C)	
08h	R/W	External Diode 1 Low Limit High Byte	Stores the integer portion of the low limit for External Diode 1 (mirrored at register 0Eh)	00h (0°C)	
09h	R/W	Configuration	Controls the general operation of the device (mirrored at address 03h)	00h	Page 31
0Ah	R/W	Conversion Rate	Controls the conversion rate for updating temperature data (mirrored at address 04h)	06h (4/sec)	Page 32

Table 6.1 Register Set in Hexadecimal Order (continued)

REGISTER ADDRESS	R/W	REGISTER NAME	FUNCTION	DEFAULT VALUE	PAGE
0Bh	R/W	Internal Diode High Limit	Stores the 8-bit high limit for the Internal Diode (mirrored at address 05h)	55h (85°C)	Page 33
0Ch	R/W	Internal Diode Low Limit	Stores the 8-bit low limit for the Internal Diode (mirrored at address 06h)	00h (0°C)	
0Dh	R/W	External Diode 1 High Limit High Byte	Stores the integer portion of the high limit for External Diode 1 (mirrored at register 07h)	55h (85°C)	
0Eh	R/W	External Diode 1 Low Limit High Byte	Stores the integer portion of the low limit for External Diode 1 (mirrored at register 08h)	00h (0°C)	
0Fh	W	One shot	A write to this register initiates a one shot update.	00h	Page 35
10h	R	External Diode 1 Data Low Byte	Stores the fractional data for External Diode 1	00h	Page 30
11h	R/W	Scratchpad	Scratchpad register for software compatibility	00h	Page 35
12h	R/W	Scratchpad	Scratchpad register for software compatibility	00h	Page 35
13h	R/W	External Diode 1 High Limit Low Byte	Stores the fractional portion of the high limit for External Diode 1	00h	Page 33
14h	R/W	External Diode 1 Low Limit Low Byte	Stores the fractional portion of the low limit for External Diode 1	00h	
15h	R/W	External Diode 2 High Limit High Byte	Stores the integer portion of the high limit for External Diode 2	55h (85°C)	Page 33
16h	R/W	External DIode 2 Low Limit High Byte	Stores the integer portion of the low limit for External Diode 2	00h (0°C)	
17h	R/W	External Diode 2 High Limit Low Byte	Stores the fractional portion of the high limit External Diode 2	00h	Page 33
18h	R/W	External Diode 2 Low Limit Low Byte	Stores the fractional portion of the low limit for External Diode 2	00h	
19h	R/W	External Diode 1 THERM Limit	Stores the 8-bit critical temperature limit for External Diode 1	55h (85°C)	Page 35
1Ah	R/W	External Diode 2 THERM Limit	Stores the 8-bit critical temperature limit for External Diode 2	55h (85°C)	Page 35
1Bh	R-C	External Diode Fault	Stores status bits indicating which external diode detected a diode fault	00h	Page 36
1Fh	R/W	Channel Mask Register	Controls the masking of individual channels	00h	Page 36

Table 6.1 Register Set in Hexadecimal Order (continued)

REGISTER ADDRESS	R/W	REGISTER NAME	FUNCTION	DEFAULT VALUE	PAGE
20h	R/W	Internal Diode THERM Limit	Stores the 8-bit critical temperature limit for the Internal Diode	55h (85°C)	Page 35
21h	R/W	THERM Hysteresis	Stores the 8-bit hysteresis value that applies to all THERM limits	0Ah (10°C)	
22h	R/W	Consecutive ALERT	Controls the number of out-of-limit conditions that must occur before an interrupt is asserted	70h	Page 37
23h	R	External Diode 2 Data High Byte	Stores the integer data for External Diode 2	00h	Page 30
24h	R	External Diode 2 Data Low Byte	Stores the fractional data for External Diode 2	00h	
25h	R/W	External Diode 1 Beta Configuration	Stores the Beta Compensation circuitry settings for External Diode 1	08h	Page 38
26h	R/W	External Diode 2 Beta Configuration	Stores the Beta Compensation circuitry settings for External Diode 2	08h or 07h	Page 38
27h	R/W	External Diode 1 Ideality Factor	Stores the ideality factor for External Diode 1	12h (1.008)	Page 39
28h	R/W	External Diode 2 Ideality Factor	Stores the ideality factor for External Diode 2	12h (1.008)	Page 39
29h	R	Internal Diode Data Low Byte	Stores the fractional data for the Internal Diode	00h	Page 30
2Ah	R	External Diode 3 High Byte	Stores the integer data for External Diode 3	00h	Page 30
2Bh	R	External Diode 3 Low Byte	Stores the fractional data for External Diode 3	00h	
2Ch	R/W	External Diode 3 High Limit High Byte	Stores the integer portion of the high limit for External Diode 3	55h (85°C)	Page 33
2Dh	R/W	External Diode 3 Low Limit High Byte	Stores the integer portion of the low limit for External Diode 3	00h (0°C)	
2Eh	R/W	External Diode 3 High Limit Low Byte	Stores the fractional portion of the high limit for External Diode 3	00h	
2Fh	R/W	External Diode 3 Low Limit Low Byte	Stores the fractional portion of the low limit for External Diode 3	00h	
30h	R/W	External Diode 3 THERM Limit	Stores the 8-bit critical temperature limit for External Diode 3	55h (85°C)	Page 35
31h	R/W	External Diode 3 Ideality Factor	Stores the ideality factor for External Diode 3	12h (1.008)	Page 39
35h	R-C	High Limit Status	Status bits for the High Limits	00h	Page 41
36h	R-C	Low Limit Status	Status bits for the Low Limits	00h	Page 41

Table 6.1 Register Set in Hexadecimal Order (continued)

REGISTER ADDRESS	R/W	REGISTER NAME	FUNCTION	DEFAULT VALUE	PAGE
37h	R	THERM Limit Status	Status bits for the THERM Limits	00h	Page 42
40h	R/W	Filter Control	Controls the digital filter setting for the External Diode 1 channel	00h	Page 42
FDh	R	Product ID	Stores a fixed value that identifies each product	Table 6.25	Page 43
FEh	R	SMSC ID	Stores a fixed value that represents SMSC	5Dh	Page 43
FFh	R	Revision	Stores a fixed value that represents the revision number	01h or 04h	Page 44

6.1 Data Read Interlock

When any temperature channel high byte register is read, the corresponding low byte is copied into an internal 'shadow' register. The user is free to read the low byte at any time and be guaranteed that it will correspond to the previously read high byte. Regardless if the low byte is read or not, reading from the same high byte register again will automatically refresh this stored low byte data.

6.2 Temperature Data Registers

Table 6.2 Temperature Data Registers

ADDR	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
00h	R	Internal Diode High Byte	128	64	32	16	8	4	2	1	00h
29h	R	Internal Diode Low Byte	0.5	0.25	0.125	-	-	-	-	-	00h
01h	R	External Diode 1 High Byte	128	64	32	16	8	4	2	1	00h
10h	R	External Diode 1 Low Byte	0.5	0.25	0.125	-	-	-	-	-	00h
23h	R	External Diode 2 High Byte	128	64	32	16	8	4	2	1	00h
24h	R	External Diode 2 Low Byte	0.5	0.25	0.125	-	-	-	-	-	00h
2Ah	R	External Diode 3 High Byte	128	64	32	16	8	4	2	1	00h
2Bh	R	External Diode 3 Low Byte	0.5	0.25	0.125	-	-	-	-	-	00h

As shown in Table 6.2, all temperatures are stored as an 11-bit value with the high byte representing the integer value and the low byte representing the fractional value left justified to occupy the MSBits.

6.3 Status Register

Table 6.3 Status Register

ADDR	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
02h	R	Status	BUSY	-	-	HIGH	LOW	FAULT	THERM	-	00h

The Status Register reports general error conditions. To identify specific channels, refer to Section 6.10, Section 6.15, Section 6.16, and Section 6.17. The individual Status Register bits are cleared when the appropriate High Limit, Low Limit, or THERM Limit register has been read or cleared.

Bit 7 - BUSY - This bit indicates that the ADC is currently converting. This bit does not cause either the $\overline{\text{ALERT}}$ or $\overline{\text{THERM}}$ pins to be asserted.

Bit 4 - HIGH - This bit is set when any of the temperature channels exceeds its programmed high limit. See the High Limit Status Register for specific channel information (Section 6.15). When set, this bit will assert the $\overline{\text{ALERT}}$ pin.

Bit 3 - LOW - This bit is set when any of the temperature channels drops below its programmed low limit. See the Low Limit Status Register for specific channel information (Section 6.16). When set, this bit will assert the $\overline{\text{ALERT}}$ pin.

Bit 2 - FAULT - This bit is asserted when a diode fault is detected on any of the external diode channels. See the External Diode Fault Register for specific channel information (Section 6.10). When set, this bit will assert the $\overline{\text{ALERT}}$ pin.

Bit 1 - THERM - This bit is set when the any of the temperature channels exceeds its programmed THERM limit. See the THERM Limit Status Register for specific channel information (Section 6.17). When set, this bit will assert the $\overline{\text{THERM}}$ pin.

6.4 Configuration Register

Table 6.4 Configuration Register

ADDR	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
03h 09h	R/W	Configuration	MASK_ ALL	RUN/ STOP	ALERT/ COMP	RECD1	RECD2	RANGE	DAVG_ DIS	- APDD	00h

The Configuration Register controls the basic operation of the device. This register is fully accessible at either address.

Bit 7 - MASK_ALL - Masks the $\overline{\text{ALERT}}$ pin from asserting.

- '0' (default) - The $\overline{\text{ALERT}}$ pin is not masked. If any of the appropriate status bits are set the $\overline{\text{ALERT}}$ pin will be asserted.
- '1' - The $\overline{\text{ALERT}}$ pin is masked. It will not be asserted for any interrupt condition unless it is configured as a secondary $\overline{\text{THERM}}$ pin. The Status Registers will be updated normally.

Bit 6 - RUN / STOP - Controls Active/Standby modes.

- '0' (default) - The device is in Active mode and converting on all channels.
- '1' -The device is in Standby mode and not converting.

Bit 5 - ALERT/COMP - Controls the operation of the $\overline{\text{ALERT}}$ pin.

- '0' (default) - The $\overline{\text{ALERT}}$ pin acts as described in Section 5.3.
- '1' - The $\overline{\text{ALERT}}$ pin acts in comparator mode as described in Section 5.3.2. In this mode the MASK_ALL bit is ignored.

Bit 4 - RECD1 - Disables the Resistance Error Correction (REC) for External Diode 1.

- '0' (default)- REC is enabled for External Diode 1.
- '1' - REC is disabled for External Diode 1.

Bit 3 - RECD2 - Disables the Resistance Error Correction (REC) for External Diode 2 and External Diode 3.

- '0' (default) - REC is enabled for External Diode 2 and External Diode 3.
- '1' - REC is disabled for External Diode 2 and External Diode 3.

Bit 2 - RANGE - Configures the measurement range and data format of the temperature channels.

- '0' (default) - The temperature measurement range is 0°C to +127.875°C and the data format is binary.
- '1' -The temperature measurement range is -64°C to +191.875°C and the data format is offset binary (see Table 5.3).

Bit 1 - DAVG_DIS - Disables the dynamic averaging feature on all temperature channels.

- '0' (default) - The dynamic averaging feature is enabled. All temperature channels will be converted with an averaging factor that is based on the conversion rate as shown in Table 5.1 and Table 5.2.
- '1' - The dynamic averaging feature is disabled. All temperature channels will be converted with a maximum averaging factor of 1x (equivalent to 11-bit conversion). For higher conversion rates, this averaging factor will be reduced as shown in Table 5.1 and Table 5.2.

Bit 0 - APDD (EMC1404 only) - Disables the anti-parallel diode operation. Beta Compensation is disabled on External Diode 2 and 3 regardless of APDD setting. In addition, External Diode 2 Beta Configuration register will be ignored.

- '0' (default) - Anti-parallel diode mode is enabled. Two external diodes will be measured on the DP2 and DN2 pins.
- '1' - Anti-parallel diode mode is disabled. Only one external diode will be measured on the DP2 and DN2 pins.

6.5 Conversion Rate Register

Table 6.5 Conversion Rate Register

ADDR	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
04h 0Ah	R/W	Conversion Rate	-	-	-	-	CONV[3:0]				06h (4/sec)

The Conversion Rate Register controls how often the temperature measurement channels are updated and compared against the limits. This register is fully accessible at either address.

Bits 3-0 - CONV[3:0] - Determines the conversion rate as shown in Table 6.6.

Table 6.6 Conversion Rate

CONV[3:0]					CONVERSIONS / SECOND
HEX	**3**	**2**	**1**	**0**	
0h	0	0	0	0	1 / 16
1h	0	0	0	1	1 / 8
2h	0	0	1	0	1 / 4
3h	0	0	1	1	1 / 2
4h	0	1	0	0	1
5h	0	1	0	1	2
6h	0	1	1	0	4 (default)
7h	0	1	1	1	8
8h	1	0	0	0	16
9h	1	0	0	1	32
Ah	1	0	1	0	64
Bh - Fh	All others				1

6.6 Limit Registers

Table 6.7 Temperature Limit Registers

ADDR.	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
05h 0Bh	R/W	Internal Diode High Limit	128	64	32	16	8	4	2	1	55h (85°C)
06h 0Ch	R/W	Internal Diode Low Limit	128	64	32	16	8	4	2	1	00h (0°C)
07h 0Dh	R/W	External Diode 1 High Limit High Byte	128	64	32	16	8	4	2	1	55h (85°C)
13h	R/W	External Diode 1 High Limit Low Byte	0.5	0.25	0.125	-	-	-	-	-	00h
08h 0Eh	R/W	External Diode 1 Low Limit High Byte	128	64	32	16	8	4	2	1	00h (0°C)

Table 6.7 Temperature Limit Registers (continued)

ADDR.	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
14h	R/W	External Diode 1 Low Limit Low Byte	0.5	0.25	0.125	-	-	-	-	-	00h
15h	R/W	External Diode 2 High Limit High Byte	128	64	32	16	8	4	2	1	55h (85°C)
16h	R/W	External Diode 2 Low Limit High Byte	128	64	32	16	8	4	2	1	00h (0°C)
17h	R/W	External Diode 2 High Limit Low Byte	0.5	0.25	0.125	-	-	-	-	-	00h
18h	R/W	External Diode 2 Low Limit Low Byte	0.5	0.25	0.125	-	-	-	-	-	00h
2Ch	R/W	External Diode 3 High Limit High Byte	128	64	32	16	8	4	2	1	55h (85°C)
2Dh	R/W	External Diode 3 Low Limit High Byte	128	64	32	16	8	4	2	1	00h (0°C)
2Eh	R/W	External Diode 3 High Limit Low Byte	0.5	0.25	0.125	-	-	-	-	-	00h
2Fh	R/W	External Diode 3 Low Limit Low Byte	0.5	0.25	0.125	-	-	-	-	-	00h

The device contains both high and low limits for all temperature channels. If the measured temperature exceeds the high limit, then the corresponding status bit is set and the $\overline{\text{ALERT}}$ pin is asserted. Likewise, if the measured temperature is less than or equal to the low limit, the corresponding status bit is set and the $\overline{\text{ALERT}}$ pin is asserted.

The data format for the limits must match the selected data format for the temperature so that if the extended temperature range is used, the limits must be programmed in the extended data format.

The limit registers with multiple addresses are fully accessible at either address.

When the device is in standby mode, updating the limit registers will have no affect until the next conversion cycle occurs. This can be initiated via a write to the One Shot Register or by clearing the RUN / STOP bit in the Configuration Register (see Section 6.4).

6.7 Scratchpad Registers

Table 6.8 Scratchpad Register

ADDR	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
11h	R/W	Scratchpad	7	6	5	4	3	2	1	0	00h
12h	R/W	Scratchpad	7	6	5	4	3	2	1	0	00h

The Scratchpad Registers are Read Write registers that are used for place holders to be software compatible with legacy programs. Reading from the registers will return what is written to them.

6.8 One Shot Register

Table 6.9 One Shot Register

ADDR.	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
0Fh	W	One Shot	Writing to this register initiates a single conversion cycle. Data is not stored and always reads 00h								00h

The One Shot Register is used to initiate a one shot command. Writing to the one shot register, when the device is in standby mode and BUSY bit (in Status Register) is ‘0’, will immediately cause the ADC to update all temperature measurements. Writing to the One Shot Register while the device is in active mode will have no affect.

6.9 Therm Limit Registers

Table 6.10 Therm Limit Registers

ADDR.	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
19h	R/W	External Diode 1 THERM Limit	128	64	32	16	8	4	2	1	55h (85°C)
1Ah	R/W	External Diode 2 THERM Limit	128	64	32	16	8	4	2	1	55h (85°C)
20h	R/W	Internal Diode THERM Limit	128	64	32	16	8	4	2	1	55h (85°C)
21h	R/W	THERM Hysteresis	128	64	32	16	8	4	2	1	0Ah (10°C)
30h	R/W	External Diode 3 THERM Limit	128	64	32	16	8	4	2	1	55h (85°C)

The THERM Limit Registers are used to determine whether a critical thermal event has occurred. If the measured temperature exceeds the THERM Limit, then the $\overline{\text{THERM}}$ pin is asserted. The limit setting must match the chosen data format of the temperature reading registers.

Unlike the $\overline{\text{ALERT}}$ pin, the $\overline{\text{THERM}}$ pin cannot be masked. Additionally, the $\overline{\text{THERM}}$ pin will be released once the temperature drops below the corresponding threshold minus the THERM Hysteresis.

6.10 External Diode Fault Register

Table 6.11 External Diode Fault Register

ADDR.	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
1Bh	R-C	External Diode Fault	-	-	-	-	E3FLT	E2FLT	E1FLT	-	00h

The External Diode Fault Register indicates which of the external diodes caused the FAULT bit in the Status Register to be set. This register is cleared when it is read.

Bit 3 - E3FLT - This bit is set if the External Diode 3 channel reported a diode fault.

Bit 2 - E2FLT - This bit is set if the External Diode 2 channel reported a diode fault.

Bit 1 - E1FLT - This bit is set if the External Diode 1 channel reported a diode fault.

6.11 Channel Mask Register

Table 6.12 Channel Mask Register

ADDR.	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
1Fh	R/W	Channel Mask	-	-	-	-	E3 MASK	E2 MASK	E1 MASK	INT MASK	00h

The Channel Mask Register controls individual channel masking. When a channel is masked, the $\overline{\text{ALERT}}$ pin will not be asserted when the masked channel reads a diode fault or out of limit error. The channel mask does not mask the $\overline{\text{THERM}}$ pin.

Bit 3 - E3MASK - Masks the $\overline{\text{ALERT}}$ pin from asserting when the External Diode 3 channel is out of limit or reports a diode fault.

- '0' (default) - The External Diode 3 channel will cause the $\overline{\text{ALERT}}$ pin to be asserted if it is out of limit or reports a diode fault.
- '1' - The External Diode 3 channel will not cause the $\overline{\text{ALERT}}$ pin to be asserted if it is out of limit or reports a diode fault.

Bit 2 - E2MASK - Masks the $\overline{\text{ALERT}}$ pin from asserting when the External Diode 2 channel is out of limit or reports a diode fault.

- '0' (default) - The External Diode 2 channel will cause the $\overline{\text{ALERT}}$ pin to be asserted if it is out of limit or reports a diode fault.
- '1' - The External Diode 2 channel will not cause the $\overline{\text{ALERT}}$ pin to be asserted if it is out of limit or reports a diode fault.

Bit 1 - E1MASK - Masks the $\overline{\text{ALERT}}$ pin from asserting when the External Diode 1 channel is out of limit or reports a diode fault.

- '0' (default) - The External Diode 1 channel will cause the $\overline{\text{ALERT}}$ pin to be asserted if it is out of limit or reports a diode fault.
- '1' - The External Diode 1 channel will not cause the $\overline{\text{ALERT}}$ pin to be asserted if it is out of limit or reports a diode fault.

Bit 0 - INTMASK - Masks the $\overline{\text{ALERT}}$ pin from asserting when the Internal Diode temperature is out of limit.

- '0' (default) - The Internal Diode channel will cause the $\overline{\text{ALERT}}$ pin to be asserted if it is out of limit.
- '1' - The Internal Diode channel will not cause the $\overline{\text{ALERT}}$ pin to be asserted if it is out of limit.

6.12 Consecutive ALERT Register

Table 6.13 Consecutive ALERT Register

ADDR.	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
22h	R/W	Consecutive ALERT	TIME OUT	CTHRM[2:0]			CALRT[2:0]			-	70h

The Consecutive ALERT Register determines how many times an out-of-limit error or diode fault must be detected in consecutive measurements before the $\overline{\text{ALERT}}$ or THERM pin is asserted. Additionally, the Consecutive ALERT Register controls the SMBus Timeout functionality.

An out-of-limit condition (i.e. HIGH, LOW, or FAULT) occurring on the same temperature channel in consecutive measurements will increment the consecutive alert counter. The counters will also be reset if no out-of-limit condition or diode fault condition occurs in a consecutive reading.

When the ALERT pin is configured as an interrupt, when the consecutive alert counter reaches its programmed value, the following will occur: the STATUS bit(s) for that channel and the last error condition(s) (i.e. E1HIGH, or E2LOW and/or E2FAULT) will be set to '1', the $\overline{\text{ALERT}}$ pin will be asserted, the consecutive alert counter will be cleared, and measurements will continue.

When the $\overline{\text{ALERT}}$ pin is configured as a comparator, the consecutive alert counter will ignore diode fault and low limit errors and only increment if the measured temperature exceeds the High Limit. Additionally, once the consecutive alert counter reaches the programmed limit, the $\overline{\text{ALERT}}$ pin will be asserted, but the counter will not be reset. It will remain set until the temperature drops below the High Limit minus the THERM Hysteresis value.

For example, if the CALRT[2:0] bits are set for 4 consecutive alerts on an EMC1403 device, the high limits are set at 70°C, and none of the channels are masked, then the $\overline{\text{ALERT}}$ pin will be asserted after the following four measurements:

1. Internal Diode reads 71°C and both external diodes read 69°C. Consecutive alert counter for INT is incremented to 1.
2. Both Internal Diode and External Diode 1 read 71°C and External Diode 2 reads 68°C. Consecutive alert counter for INT is incremented to 2 and for EXT1 is set to 1.
3. The External Diode 1 reads 71°C and both the Internal Diode and External Diode 2 read 69°C. Consecutive alert counter for INT and EXT2 are cleared and EXT1 is incremented to 2.
4. The Internal Diode reads 71°C and both external diodes read 71°C. Consecutive alert counter for INT is set to 1, EXT2 is set to 1, and EXT1 is incremented to 3.
5. The Internal Diode reads 71°C and both the external diodes read 71°C. Consecutive alert counter for INT is incremented to 2, EXT2 is set to 2, and EXT1 is incremented to 4. The appropriate status bits are set for EXT1 and the $\overline{\text{ALERT}}$ pin is asserted. EXT1 counter is reset to 0 and all other counters hold the last value until the next temperature measurement.

Bit 7 - TIMEOUT - Determines whether the SMBus Timeout function is enabled.

- '0' (default) - The SMBus Timeout feature is disabled. The SMCLK line can be held low indefinitely without the device resetting its SMBus protocol.
- '1' - The SMBus Timeout feature is enabled. If the SMCLK line is held low for more than 30ms, then the device will reset the SMBus protocol.

Bits 6-4 - CTHRM[2:0] - Determines the number of consecutive measurements that must exceed the corresponding THERM Limit before the THERM pin is asserted. All temperature channels use this value to set the respective counters. The consecutive THERM counter is incremented whenever any measurement exceed the corresponding THERM Limit.

If the temperature drops below the THERM limit, then the counter is reset. If a number of consecutive measurements above the THERM limit occurs, then the THERM pin is asserted low.

Once the THERM pin has been asserted, the consecutive therm counter will not reset until the corresponding temperature drops below the THERM Limit minus the THERM Hysteresis value.

The bits are decoded as shown in Table 6.14. The default setting is 4 consecutive out of limit conversions.

Bits 3-1 - CALRT[2:0] - Determine the number of consecutive measurements that must have an out of limit condition or diode fault before the ALERT pin is asserted. All temperature channels use this value to set the respective counters. The bits are decoded as shown in Table 6.14. The default setting is 1 consecutive out of limit conversion.

Table 6.14 Consecutive Alert / THERM Settings

2	1	0	NUMBER OF CONSECUTIVE OUT OF LIMIT MEASUREMENTS
0	0	0	1 (default for CALRT[2:0])
0	0	1	2
0	1	1	3
1	1	1	4 (default for CTHRM[2:0])

6.13 Beta Configuration Registers

Table 6.15 Beta Configuration Registers

ADDR.	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
25h	R/W	External Diode 1 Beta Configuration	-	-	-	-	ENABLE1	BETA1[2:0]			08h
26h	R/W	External Diode 2 Beta Configuration	-	-	-	-	ENABLE2	BETA2[2:0]			08h for EMC1403 or 07h for EMC1404

This register is used to set the Beta Compensation factor that is used for the external diode channels.

Bit 3 - ENABLEx - Enables the Beta Compensation factor autodetection function. This function shall be disabled for External Diode 2.

- '0' - The Beta Compensation Factor autodetection circuitry is disabled. The External Diode will always use the Beta Compensation factor set by the BETAx[2:0] bits.
- '1' (default) - The Beta Compensation factor autodetection circuitry is enabled. At the beginning of every conversion, the optimal Beta Compensation factor setting will be determined and applied. The BETAx[2:0] bits will be automatically updated to indicate the current setting.

Bit 2-0 - BETAx[2:0] - These bits always reflect the current beta configuration settings. If autodetection circuitry is enabled, then these bits will be updated automatically and writing to these bits will have no effect. If the autodetection circuitry is disabled, then these bits will determine the beta configuration setting that is used for their respective channels.

Care should be taken when setting the BETAx[2:0] bits when the autodetection circuitry is disabled. If the Beta Compensation factor is set at a beta value that is higher than the transistor beta, then the circuit may introduce measurement errors. When measuring a discrete thermal diode (such as 2N3904) or a CPU diode that functions like a discrete thermal diode (such as an AMD processor diode), then the BETAx[2:0] bits should be set to '111b'.

Table 6.16 CPU Beta Values

HEX	ENABLEX	BETAX[2:0]			MINIMUM BETA
		2	1	0	
0h	0	0	0	0	0.11
1h	0	0	0	1	0.18
2h	0	0	1	0	0.25
3h	0	0	1	1	0.33
4h	0	1	0	0	0.43
5h	0	1	0	1	1.00
6h	0	1	1	0	2.33
7h	0	1	1	1	Disabled
8h - Fh	1	X	X	X	Autodetection

6.14 External Diode Ideality Factor Registers

Table 6.17 Ideality Configuration Registers

ADDR.	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
27h	R/W	External Diode 1 Ideality Factor	-	-	IDEALITY1[5:0]						12h
28h	R/W	External Diode 2 Ideality Factor	-	-	IDEALITY2[5:0]						12h
31h	R/W	External Diode 3 Ideality Factor	-	-	IDEALITY3[5:0]						12h

These registers store the ideality factors that are applied to the external diodes. Table 6.18 defines each setting and the corresponding ideality factor. 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 6.18 Ideality Factor Look-Up Table (Diode Model)

SETTING	FACTOR		SETTING	FACTOR		SETTING	FACTOR
08h	0.9949		18h	1.0159		28h	1.0371
09h	0.9962		19h	1.0172		29h	1.0384
0Ah	0.9975		1Ah	1.0185		2Ah	1.0397
0Bh	0.9988		1Bh	1.0200		2Bh	1.0410
0Ch	1.0001		1Ch	1.0212		2Ch	1.0423
0Dh	1.0014		1Dh	1.0226		2Dh	1.0436
0Eh	1.0027		1Eh	1.0239		2Eh	1.0449
0Fh	1.0040		1Fh	1.0253		2Fh	1.0462
10h	1.0053		20h	1.0267		30h	1.0475
11h	1.0066		21h	1.0280		31h	1.0488
12h	1.0080		22h	1.0293		32h	1.0501
13h	1.0093		23h	1.0306		33h	1.0514
14h	1.0106		24h	1.0319		34h	1.0527
15h	1.0119		25h	1.0332		35h	1.0540
16h	1.0133		26h	1.0345		36h	1.0553
17h	1.0146		27h	1.0358		37h	1.0566

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 6.19 when using a CPU substrate transistor.

Table 6.19 Substrate Diode Ideality Factor Look-Up Table (BJT Model)

SETTING	FACTOR		SETTING	FACTOR		SETTING	FACTOR
08h	0.9869		18h	1.0079		28h	1.0291
09h	0.9882		19h	1.0092		29h	1.0304
0Ah	0.9895		1Ah	1.0105		2Ah	1.0317
0Bh	0.9908		1Bh	1.0120		2Bh	1.0330
0Ch	0.9921		1Ch	1.0132		2Ch	1.0343
0Dh	0.9934		1Dh	1.0146		2Dh	1.0356
0Eh	0.9947		1Eh	1.0159		2Eh	1.0369
0Fh	0.9960		1Fh	1.0173		2Fh	1.0382
10h	0.9973		20h	1.0187		30h	1.0395

Table 6.19 Substrate Diode Ideality Factor Look-Up Table (BJT Model) (continued)

SETTING	FACTOR	SETTING	FACTOR	SETTING	FACTOR
11h	0.9986	21h	1.0200	31h	1.0408
12h	1.0000	22h	1.0213	32h	1.0421
13h	1.0013	23h	1.0226	33h	1.0434
14h	1.0026	24h	1.0239	34h	1.0447
15h	1.0039	25h	1.0252	35h	1.0460
16h	1.0053	26h	1.0265	36h	1.0473
17h	1.0066	27h	1.0278	37h	1.0486

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.

6.15 High Limit Status Register

Table 6.20 High Limit Status Register

ADDR.	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
35h	R-C	High Limit Status	-	-	-	-	E3HIGH	E2HIGH	E1HIGH	IHIGH	00h

The High Limit Status Register contains the status bits that are set when a temperature channel high limit is exceeded. If any of these bits are set, then the HIGH status bit in the Status Register is set. Reading from the High Limit Status Register will clear all bits if. Reading from the register will also clear the HIGH status bit in the Status Register.

The $\overline{\text{ALERT}}$ pin will be set if the programmed number of consecutive alert counts have been met and any of these status bits are set.

The status bits will remain set until read unless the $\overline{\text{ALERT}}$ pin is configured as a comparator output (see Section 5.3.2).

Bit 3 - E3HIGH - This bit is set when the External Diode 3 channel exceeds its programmed high limit.

Bit 2 - E2HIGH - This bit is set when the External Diode 2 channel exceeds its programmed high limit.

Bit 1 - E1HIGH - This bit is set when the External Diode 1 channel exceeds its programmed high limit.

Bit 0 - IHIGH - This bit is set when the Internal Diode channel exceeds its programmed high limit.

6.16 Low Limit Status Register

Table 6.21 Low Limit Status Register

ADDR.	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
36h	R-C	Low Limit Status	-	-	-	-	E3LOW	E2LOW	E1LOW	ILOW	00h

The Low Limit Status Register contains the status bits that are set when a temperature channel drops below the low limit. If any of these bits are set, then the LOW status bit in the Status Register is set.

Reading from the Low Limit Status Register will clear all bits. Reading from the register will also clear the LOW status bit in the Status Register.

The $\overline{\text{ALERT}}$ pin will be set if the programmed number of consecutive alert counts have been met and any of these status bits are set.

The status bits will remain set until read unless the $\overline{\text{ALERT}}$ pin is configured as a comparator output (see Section 5.3.2).

Bit 3 - E3LOW - This bit is set when the External Diode 3 channel drops below its programmed low limit.

Bit 2 - E2LOW - This bit is set when the External Diode 2 channel drops below its programmed low limit.

Bit 1 - E1LOW - This bit is set when the External Diode 1 channel drops below its programmed low limit.

Bit 0 - ILOW - This bit is set when the Internal Diode channel drops below its programmed low limit.

6.17 THERM Limit Status Register

Table 6.22 THERM Limit Status Register

ADDR.	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
37h	R-C	THERM Limit Status	-	-	-	-	E3 THERM	E2 THERM	E1 THERM	ITHERM	00h

The THERM Limit Status Register contains the status bits that are set when a temperature channel THERM Limit is exceeded. If any of these bits are set, then the THERM status bit in the Status Register is set. Reading from the THERM Limit Status Register will not clear the status bits. Once the temperature drops below the THERM Limit minus the THERM Hysteresis, the corresponding status bits will be automatically cleared. The THERM bit in the Status Register will be cleared when all individual channel THERM bits are cleared.

Bit 3 - E3THERM - This bit is set when the External Diode 3 channel exceeds its programmed THERM Limit. When set, this bit will assert the $\overline{\text{THERM}}$ pin.

Bit 2 - E2THERM - This bit is set when the External Diode 2 channel exceeds its programmed THERM Limit. When set, this bit will assert the $\overline{\text{THERM}}$ pin.

Bit 1 - E1THERM - This bit is set when the External Diode 1 channel exceeds its programmed THERM limit. When set, this bit will assert the $\overline{\text{THERM}}$ pin.

Bit 0- ITHERM - This bit is set when the Internal Diode channel exceeds its programmed THERM limit. When set, this bit will assert the $\overline{\text{THERM}}$ pin.

6.18 Filter Control Register

Table 6.23 Filter Configuration Register

ADDR.	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
40h	R/W	Filter Control	-	-	-	-	-	-	FILTER[1:0]		00h

The Filter Configuration Register controls the digital filter on the External Diode 1 channel.

Bits 1-0 - FILTER[1:0] - Control the level of digital filtering that is applied to the External Diode temperature measurements as shown in Table 6.24. See Figure 5.3and Figure 5.4 for examples on the filter behavior.

Table 6.24 Filter Settings

FILTER[1:0]		AVERAGING
1	**0**	
0	0	Disabled (default)
0	1	Level 1
1	0	Level 1
1	1	Level 2

6.19 Product ID Register

Table 6.25 Product ID Register

ADDR	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
FDh	R	Product ID	0	0	1	0	0	0	0	1	21h EMC1403
FDh	R	Product ID	0	0	1	0	0	1	0	1	25h EMC1404

The Product ID Register holds a unique value that identifies the device.

6.20 SMSC ID Register (FEh)

Table 6.26 Manufacturer ID Register

ADDR.	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
FEh	R	SMSC ID	0	1	0	1	1	1	0	1	5Dh

The Manufacturer ID register contains an 8 bit word that identifies the SMSC as the manufacturer of the EMC1403 and EMC1404.

6.21 Revision Register (FFh)

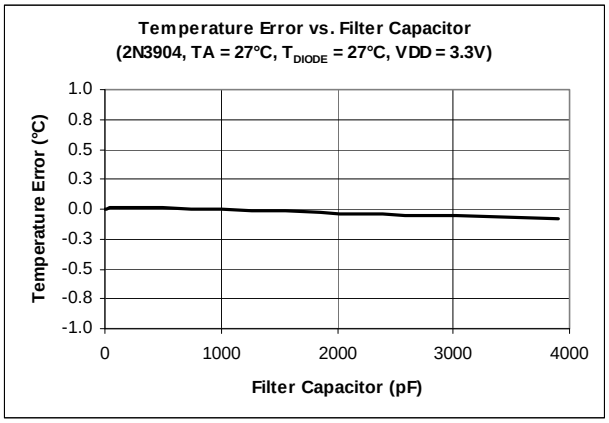
Table 6.27 Revision Register

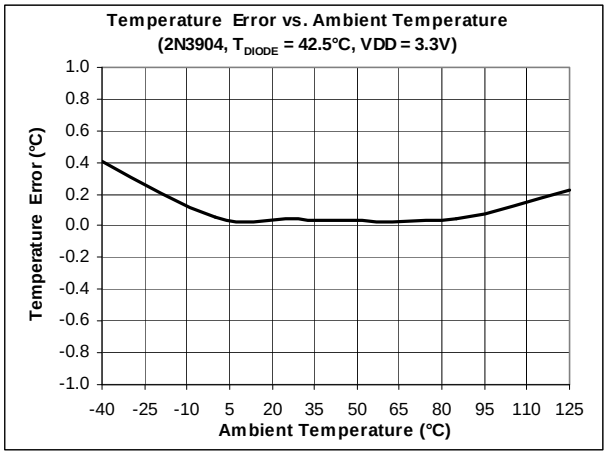
ADDR.	R/W	REGISTER	B7	B6	B5	B4	B3	B2	B1	B0	DEFAULT
FFh	R	Revision	0	0	0	0	0	0	0	1	01h
FFh	R	Revision	0	0	0	0	0	1	0	0	04h

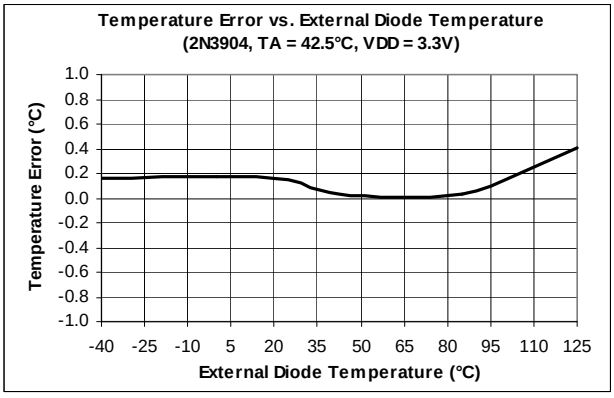
The Revision register contains an 8-bit word that identifies the die revision. It can be 01h or 04h.

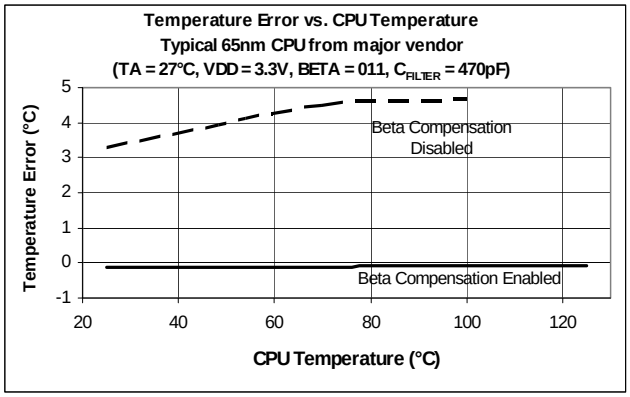
ENGINEERING NOTE:

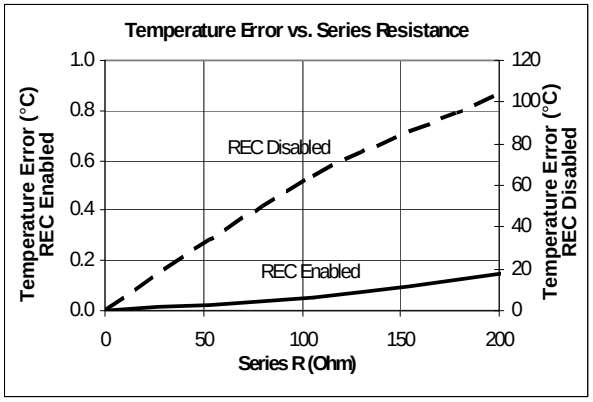
Chapter 7 Typical Operating Curves

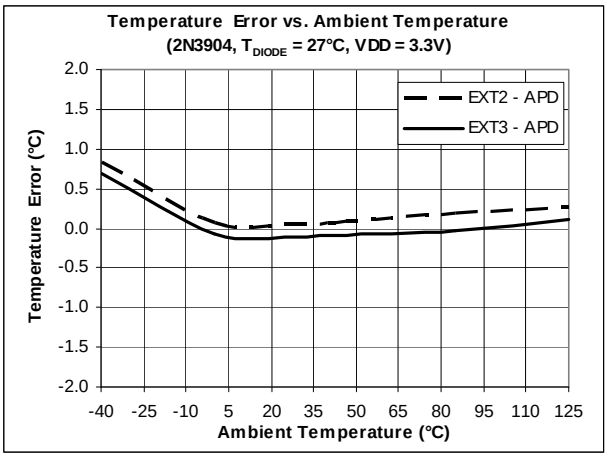


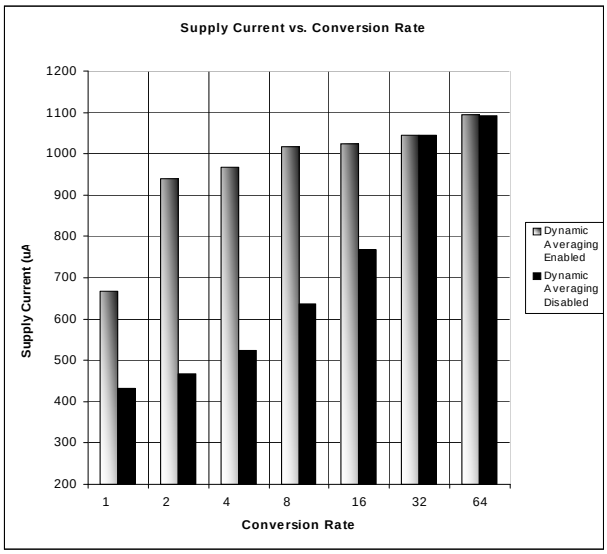







Temperature Error vs. Series Resistance
Temperature Error (°C) REC Enabled
Temperature Error (°C) REC Disabled
REC Disabled
REC Enabled
Series R (Ohm)
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100
120
0
50
100
150
200


Temperature Error vs. Ambient Temperature
(2N3904, T DIODE = 27°C, VDD = 3.3V)
Temperature Error (°C)
EXT2 - APD
EXT3 - APD
Ambient Temperature (°C)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-40
-25
-10
5
20
35
50
65
80
95
110
125


Supply Current vs. Conversion Rate
Supply Current (uA
Dynamic Averaging Enabled
Dynamic Averaging Disabled
Conversion Rate
1200
1100
1000
900
800
700
600
500
400
300
200
1
2
4
8
16
32
64

Chapter 8 Package Information

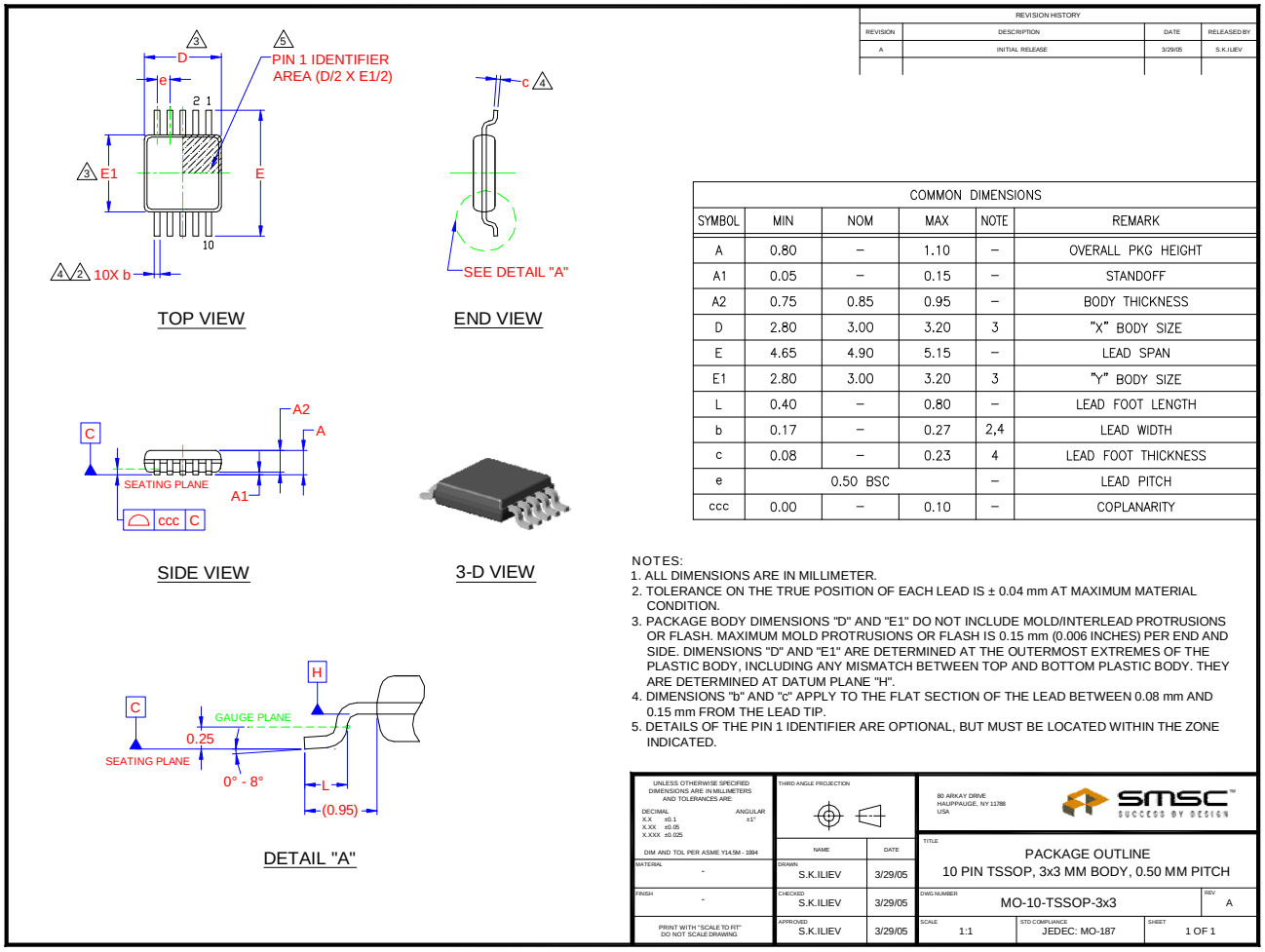


Figure 8.1 10-Pin MSOP / TSSOP Package

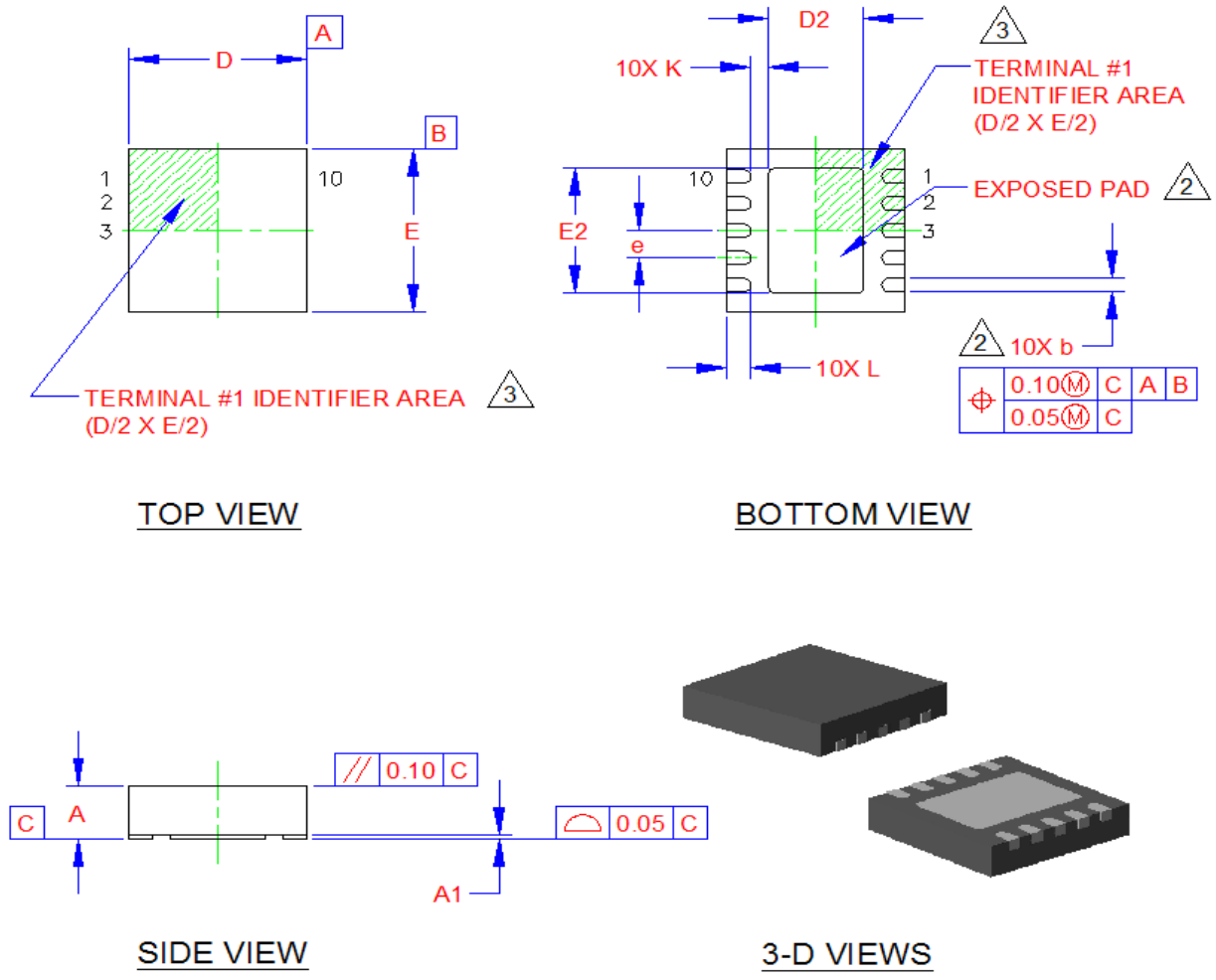
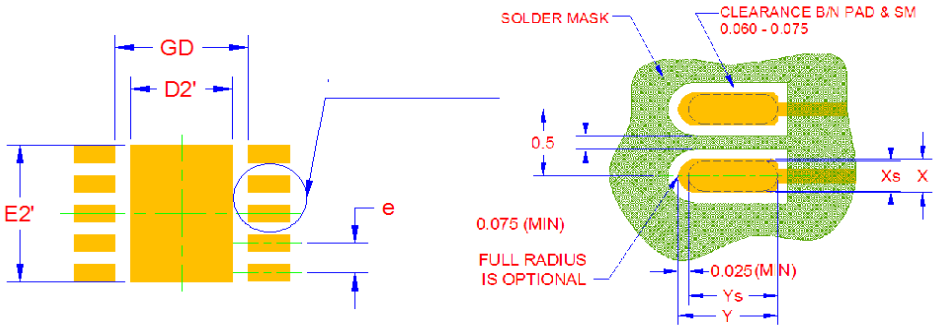


Figure 8.2 10-Pin DFN Package Drawing

COMMON DIMENSIONS					
SYMBOL	MIN	NOM	MAX	NOTE	REMARK
A	0.80	0.85	0.90	-	OVERALL PACKAGE HEIGHT
A1	0	0.02	0.05	-	STANDOFF
D/E	2.90	3.00	3.10	-	X/Y BODY SIZE
D2	1.50	1.60	1.70	2	X EXPOSED PAD SIZE
E2	2.20	2.30	2.40	2	Y EXPOSED PAD SIZE
L	0.35	0.40	0.45	-	TERMINAL LENGTH
b	0.18	0.25	0.30	2	TERMINAL WIDTH
K	0.25	0.30	-	-	TERMINAL TO PAD DISTANCE
e	0.50 BSC			-	TERMINAL PITCH

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. UNILATERAL COPLANARITY ZONE APPLIES TO THE EXPOSED PAD, AS WELL AS THE TERMINALS. DIMENSIONS "b" APPLIES TO PLATED TERMINALS AND IT IS MEASURED BETWEEN 0.15 AND 0.30 mm FROM THE TERMINAL TIP.
3. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL BUT MUST BE LOCATED WITHIN THE AREA INDICATED.

Figure 8.3 10-Pin DFN Package Dimensions



PCB LAND PATTERN

LAND PATTERN DIMENSIONS			
SYMBOL	MIN	NOM	MAX
GD	2.10	-	2.20
D2'	-	1.60	1.60
E2'	-	2.30	-
Pad: X	-	0.28	0.28
Pad: Y	-	0.69	0.69
e		0.50	

Figure 8.4 10 Pin DFN PCB Footprint

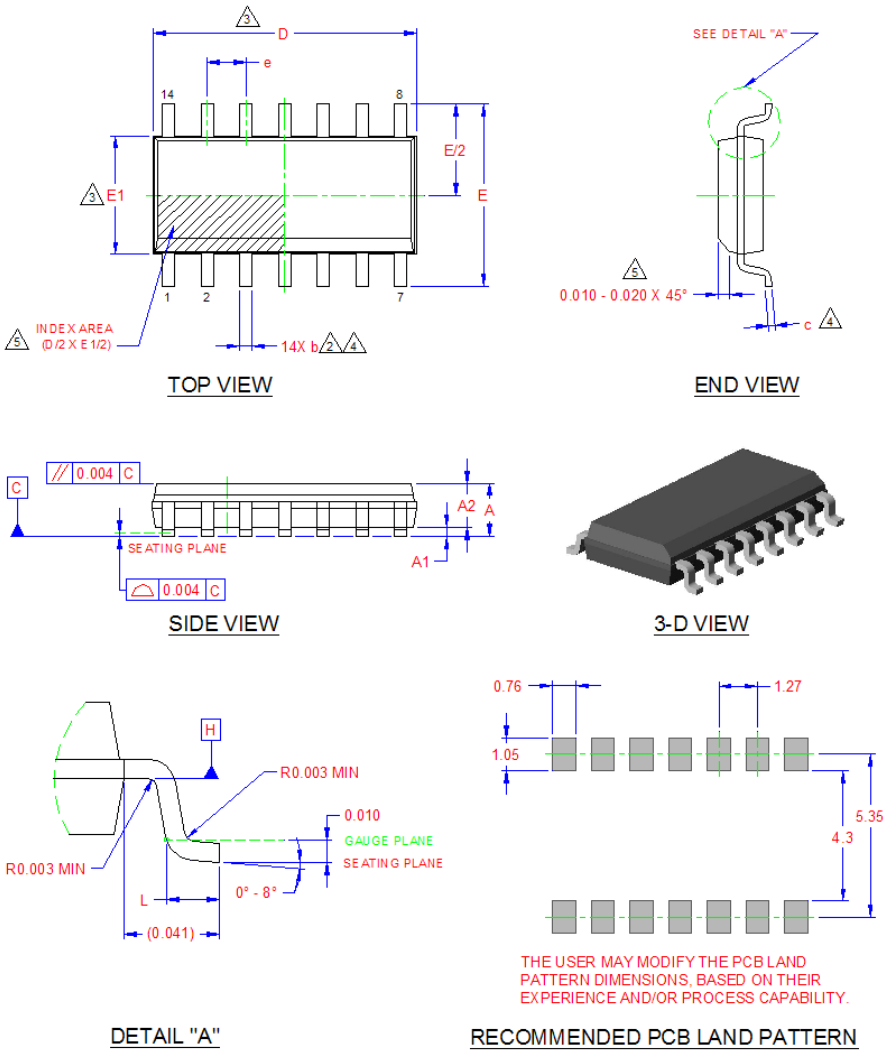


Figure 8.5 Package Drawing and PCB Footprint for SOIC-14

Common Dimensions					
Symbol	Min	Nom	Max	Note	Remark
A	1.35	-	1.75	-	OVERALL PKG HEIGHT
A1	0.10	-	0.25	-	STANDOFF
A2	1.25		1.65	-	BODY THICKNESS
D	8.53	8.64	8.74	3	"X" BODY SIZE
E	5.79	5.99	6.20	-	LEAD SPAN
E1	3.81	3.91	4.01	3	"Y" BODY SIZE
L	0.41	0.64	0.89	-	LEAD FOOT LENGTH
b	0.31	-	0.51	2,4	LEAD WIDTH
c	0.18		0.25	4	LEAD FOOT THICKNESS
e		1.27 BSC		-	LEAD PITCH
NOTES:					
1. ALL DIMENSION ARE IN mm.					
2. TRUE POSITION SPREAD TOLERANCE OF EACH LEAD IS ±0.125mm AT MAXIMUM MATERIAL CONDITION. DIMENSION "b" DOES NOT INCLUDE DAMBAR PROTUSION. DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OF THE FOOT					
3. DIMENSION "D" DOES NOT INCLUDE MODE FLASH, PROTRUSIONS, OR GATE BURRS. MAXIMUM MOLD FLASH, PROTRUSIONS, OR GATE BURRS IS 0.152MM PER END. DIMENSION "E1" DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. MAXIMUM INTERLEAD FLASH OR PROTRUSION IS 0.254MM PE					
4. "b" & "c" APPLY TOTEH FLAT SECTION OF THE LEAD BETWEEN 0.102mm AND 0.254mm FROM THE LEAD TIP.					
5. THE CHAMFER FEATURE IS OPTIONAL. IF IT IS NOT PRESENT, THEN A PIN1 IDENTIFIER MUST BE LOCATED WITHIN THE INDEX AREA INDICATED.					

Figure 8.6 Package Dimensions for SOIC-14

8.1 Package Markings

8.1.1 EMC1404-X-AIZL (10-pin MSOP)

All devices will be marked on the first line of the top side with “1404”. On the second line, they will be marked with the appropriate -X number (-1, -2, etc), the Functional Revision “B” and Country Code (CC).

8.1.2 EMC1403-X-AIZL (10-pin MSOP)

All devices will be marked on the first line of the top side with “1403”. On the second line, packages will be marked with the appropriate -X number (-1, -2, etc), the Functional Revision “B” and Country Code (CC).

8.1.3 EMC1403-1-AIA and EMC1403-2-AIA (10-pin DFN)

The EMC1403-1-AIA will be marked on the first line of the top side with the code “31” followed by the first two characters of the last 6 characters of the Lot Number. The EMC1403-2-AIA is marked with the code “32” followed by the first two characters of the last 6 characters of the Lot Number. On the second line, packages will be marked with the last 4 characters of the Lot Number.

For example: If the Lot Number is “2H123456A”, the first line on the EMC1403-1-AIA will read “3123” and the second line will read “456A”.

8.1.4 EMC1403-YZT

All devices will be marked on the first line of the top side with “EMC1403” followed by “-X” where X is the appropriate -X number (-1, -2, etc). On the second line, packages will be marked with Functional Revision “B”, date code and the last 7 characters of Lot Number.

Chapter 9 Datasheet Revision History

Table 9.1 Customer Revision History

REVISION LEVEL & DATE	SECTION/FIGURE/ENTRY	CORRECTION
Rev. 2.0 (08-10-12)	Table 3.3, "SMBus Electrical Specifications"	Added conditions for $t_{HD:DAT}$. Data hold time minimum of 0.3µs is required when receiving from the master. Data hold time is 0µs min when transmitting to the master.
	Section 6.21, "Revision Register (FFh)"	Added row to indicate that revision ID can be 04h. Revision ID may be 04h or 01h.
Rev. 1.38 (02-28-12)	Figure 2.2, "EMC1403/EMC1404 Pin Diagram, DFN-10"	Added exposed pad and updated so it looks more like a square.
	Table 2.1, "EMC1403 and EMC1404 Pin Description"	Added last row for DFN bottom pad. Recommendation is to connect it to ground.
Rev. 1.37 (01-06-10)	Section 8.1.4, "EMC1403-YZT"	Added to last sentence: “Revision “B”, date code and the last 7 characters of” before “Lot Number”.
	Section 8.1.3, "EMC1403-1-AIA and EMC1403-2-AIA (10-pin DFN)"	Corrected device code. Instead of being “32” for both devices in the 10-pin DFN package, the code is “31” for the EMC1403-1-AIA and “32” for the EMC1403-2-AIA.
Rev. 1.36 (07-02-09)	Table 2.1, "EMC1403 and EMC1404 Pin Description"	In pin description table, added to function column: “requires pull-up resistor” for SMDATA and SMCLK pins
	Table 2.1, "EMC1403 and EMC1404 Pin Description"	Identified 5V tolerant pins. Added the following application note below table: “For the 5V tolerant pins that have a pull-up resistor (SMCLK, SMDATA, THERM, and ALERT), the voltage difference between VDD and the pull-up voltage must never exceed 3.6V.”
	Table 3.1, "Absolute Maximum Ratings"	Updated voltage limits for 5V tolerant pins with pull-up resistors. Added the following note below table: “For the 5V tolerant pins that have a pull-up resistor (SMCLK, SMDATA, THERM, and ALERT), the pull-up voltage must not exceed 3.6V when the device is unpowered.”
	Table 3.2, "Electrical Specifications"	Added leakage current.
Rev. 1.35 (04-14-09)	Figure 8.2, "10-Pin DFN Package Drawing" Figure 8.3, "10-Pin DFN Package Dimensions" Figure 8.4, "10 Pin DFN PCB Footprint"	Diagrams updated
	Table 3.1, "Absolute Maximum Ratings"	Updated thermal resistance numbers

Table 9.1 Customer Revision History (continued)

REVISION LEVEL & DATE	SECTION/FIGURE/ENTRY	CORRECTION
Rev. 1.34 (02-27-09)	Table 5.3, "Temperature Data Format"	Extended range for -1 updated from 001 1111 1111 to 001 1111 1000
Rev. 1.33 (08-18-08)	Ordering Information and Table 1.1, "Part Selection"	Added EMC1403-3 and EMC1403-4 for all package options
Rev. 1.32 (07-10-08)	Ordering Information and Table 1.1, "Part Selection"	Added EMC1404-4
Rev. 1.31 (07-01-08)	Ordering Information and Table 1.1, "Part Selection"	Added EMC1404-2 and EMC1404-3

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