

# BBUS Compliant Dual Temperature Monitor with Beta Compensation

## PRODUCT FEATURES

Datasheet

### GENERAL DESCRIPTION

The EMC1212 is a temperature sensor that communicates with a host over a single-wire SMSC BudgetBus™ Sensor Interface. The EMC1212 monitors one internal diode and one remote temperature zone. Packaged in a SOT23-5, the EMC1212 provides an accurate, low-cost, low-current, solution for critical temperature monitoring in applications such as embedded systems or computers. When used in combination with an SMSC Super I/O host, such as a keyboard controller, a complete thermal management system is created. A power down mode extends battery life in portable applications. The internal 11-bit sigma delta temperature-to-digital converter provides superb linearity, high accuracy and excellent noise immunity.

The EMC1212 is designed to operate with 65nm or 90nm PNP substrate transistor used as a thermal diode with the collector connected to ground.

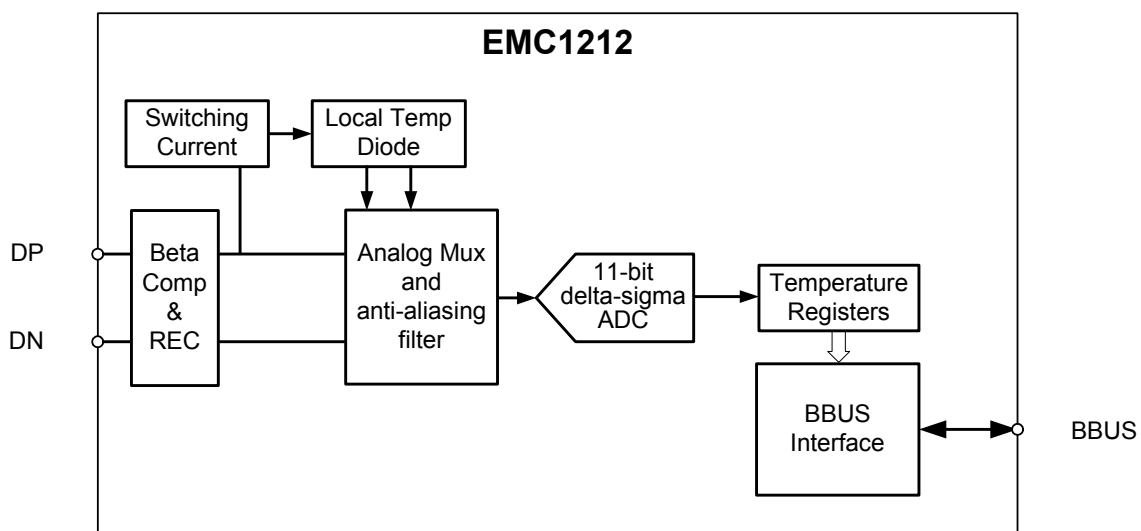
### APPLICATIONS

- Desktop and Notebook Computers
- Hardware Management

### FEATURES

- Single Wire BBUS Interface
- Resistance Error Correction
- Beta Compensation
- External Temperature Monitor
  - 0.125°C resolution
  - ±1°C Accuracy 60°C to 100°C
  - Diode Fault Reporting
- Internal Temperature Monitor
  - Range 0°C to +85°C
  - 0.125°C resolution
  - ±1.5°C Accuracy 50°C to 70°C
- Supply:
  - 3.0V to 3.6V
  - <5uA in Standby

### SIMPLIFIED BLOCK DIAGRAM



**ORDER NUMBER(S):**  
**EMC1212-AGZQ-TR FOR 5 PIN, SOT LEAD-FREE ROHS COMPLIANT PACKAGE**  
**REEL SIZE IS 2,500 PIECES**  
**EVALUATION BOARD AVAILABLE UPON REQUEST (EVB-KBC1100)**



80 ARKAY DRIVE, HAUPPAUGE, NY 11788 (631) 435-6000, FAX (631) 273-3123

Copyright © 2007 SMSC or its subsidiaries. All rights reserved.

Circuit diagrams and other information relating to SMSC products are included as a means of illustrating typical applications. Consequently, complete information sufficient for construction purposes is not necessarily given. Although the information has been checked and is believed to be accurate, no responsibility is assumed for inaccuracies. SMSC reserves the right to make changes to specifications and product descriptions at any time without notice. Contact your local SMSC sales office to obtain the latest specifications before placing your product order. The provision of this information does not convey to the purchaser of the described semiconductor devices any licenses under any patent rights or other intellectual property rights of SMSC or others. All sales are expressly conditional on your agreement to the terms and conditions of the most recently dated version of SMSC's standard Terms of Sale Agreement dated before the date of your order (the "Terms of Sale Agreement"). The product may contain design defects or errors known as anomalies which may cause the product's functions to deviate from published specifications. Anomaly sheets are available upon request. SMSC products are not designed, intended, authorized or warranted for use in any life support or other application where product failure could cause or contribute to personal injury or severe property damage. Any and all such uses without prior written approval of an Officer of SMSC and further testing and/or modification will be fully at the risk of the customer. Copies of this document or other SMSC literature, as well as the Terms of Sale Agreement, may be obtained by visiting SMSC's website at <http://www.smsc.com>. SMSC is a registered trademark of Standard Microsystems Corporation ("SMSC"). Product names and company names are the trademarks of their respective holders.

SMSC DISCLAIMS AND EXCLUDES ANY AND ALL WARRANTIES, INCLUDING WITHOUT LIMITATION ANY AND ALL IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, TITLE, AND AGAINST INFRINGEMENT AND THE LIKE, AND ANY AND ALL WARRANTIES ARISING FROM ANY COURSE OF DEALING OR USAGE OF TRADE. IN NO EVENT SHALL SMSC BE LIABLE FOR ANY DIRECT, INCIDENTAL, INDIRECT, SPECIAL, PUNITIVE, OR CONSEQUENTIAL DAMAGES; OR FOR LOST DATA, PROFITS, SAVINGS OR REVENUES OF ANY KIND; REGARDLESS OF THE FORM OF ACTION, WHETHER BASED ON CONTRACT; TORT; NEGLIGENCE OF SMSC OR OTHERS; STRICT LIABILITY; BREACH OF WARRANTY; OR OTHERWISE; WHETHER OR NOT ANY REMEDY OF BUYER IS HELD TO HAVE FAILED OF ITS ESSENTIAL PURPOSE, AND WHETHER OR NOT SMSC HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

## Chapter 1 Pin Description

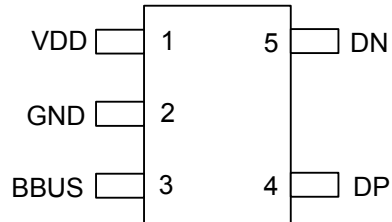


Figure 1.1 Pin Diagram for EMC1212

Table 1.1 Pin Description

PIN NUMBER	NAME	FUNCTION
1	VDD	Supply Voltage
2	GND	Ground
3	BBUS	Serial bus interface to SMSC host
4	DP	Remote diode positive terminal
5	DN	Remote diode negative terminal

## Chapter 2 Electrical Specifications

### 2.1 Absolute Maximum Ratings

Table 2.1 EMC1212 Maximum Ratings

DESCRIPTION	RATING	UNIT
Supply Voltage $V_{DD}$	-0.3 to 5.0	V
Voltage on any other pin to GND	-0.3 to $V_{DD} + 0.3$	V
Operating Temperature Range	0 to 85	°C
Storage Temperature Range	-55 to 150	°C
Lead Temperature Range	Refer to JEDEC Spec. J-STD-020	
Package Thermal Characteristics for SOT23-5		
Power Dissipation	TBD	
Thermal Resistance(at 0 air flow)	131.7	°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

$V_{DD} = 3.3V \pm 10\%$   $T_A = 0^\circ\text{C}$  to  $85^\circ\text{C}$ , all Typical values at  $T_A = 27^\circ\text{C}$  unless otherwise noted.

CHARACTERISTIC	SYMBOL	MIN	TYP	MAX	UNIT	CONDITIONS
DC Power						
Supply Voltage	$V_{DD}$	3	3.3	3.6	V	
Supply Current	$I_{DD}$		700	1000	uA	Active Mode
Supply Current	$I_{DD}$		2	5	uA	Standby Mode
Internal Temperature Monitor						
Temperature Accuracy			±1	±3	°C	
				±1.5	°C	$50^\circ\text{C} < T_A < 70^\circ\text{C}$
Temperature Resolution			0.125		°C	

## Datasheet

CHARACTERISTIC	SYMBOL	MIN	TYP	MAX	UNIT	CONDITIONS
External Temperature Monitor						
Temperature Accuracy			±0.5	±1	°C	60°C < T <sub>DIODE</sub> < 100°C, 10°C < T <sub>A</sub> < 70°C
				±1	±3	°C
Temperature Resolution			0.125		°C	
Conversion Time per Channel	t <sub>CONV</sub>		21		mS	
Capacitive Load	C <sub>LOAD</sub>			400	pF	Connected across remote diode

## 2.3 BudgetBus Electrical Characteristics

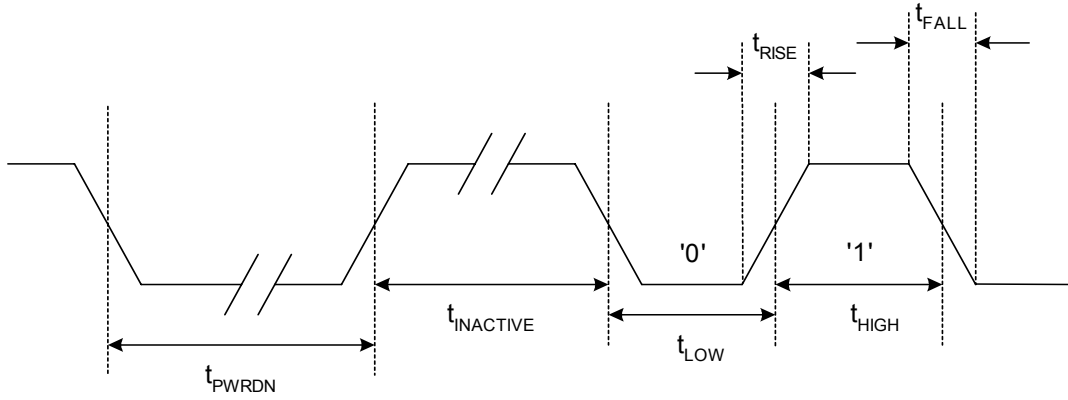
V<sub>DD</sub> = 3V to 3.6V, T<sub>A</sub> = 0°C to 85°C, Typical values are at T<sub>A</sub> = 27°C unless otherwise noted.

CHARACTERISTIC	SYMBOL	MIN	TYP	MAX	UNITS	CONDITIONS
Output High Voltage	V <sub>OH</sub>	2.4			V	2mA Sourcing current
Output Low Voltage	V <sub>OL</sub>			0.4	V	4mA Sinking Current
Input High Voltage	V <sub>IH</sub>	2.4			V	
Input Low Voltage	V <sub>IL</sub>			0.4	V	
AC Parameters						
Input Capacitance	C <sub>IN</sub>			10	pF	
Bus Single Bit High Time or Low Time	T <sub>HIGH</sub> / T <sub>LOW</sub>	8	10	12	us	
Inactive Time	T <sub>INACTIVE</sub>	132			us	Between Consecutive packets or after power up
Power Down Time	T <sub>PWRDN</sub>	264			us	To initiate power down
Rise Time	T <sub>RISE</sub>			400	ns	
Fall Time	T <sub>FALL</sub>			400	ns	

## 2.4 BudgetBus Protocol

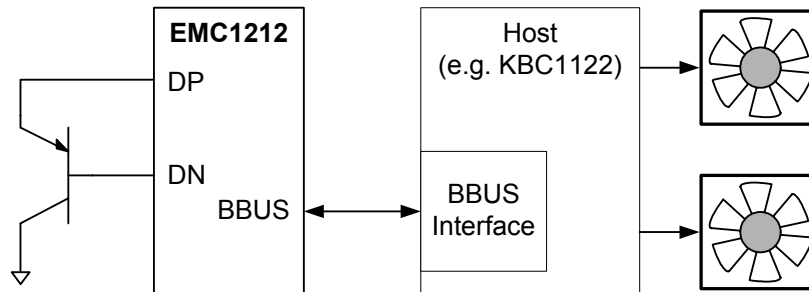
The EMC1212 communicates with a host controller, such as the SMSC KBC1100, through the proprietary single wire SMSC BudgetBus™ Sensor Interface known as BBUS. The BBUS is a single wire serial communication protocol between the computer host and its peripheral devices. Please refer to the BBUS Specification for detailed information about the modes of operation.

The BudgetBus timing is shown in [Figure 2.1](#). This timing applies to all BudgetBus communication bits.


**Figure 2.1 BudgetBus Bit Timing**

## Chapter 3 Product Description

The EMC1212 is a SOT23 temperature sensor with a proprietary single wire SMSC BudgetBus™ Sensor Interface. Temperature information is communicated to a host device via the serial bus. All intelligence regarding the interpretation of temperature resides in the host. The EMC1212 monitors an internal diode and single external transistor and automatically corrects for errors induced by series resistance and beta variation. Figure 3.1 shows a typical system overview:



**Figure 3.1 System Diagram of EMC1212**

Thermal management consists of the host acquiring the temperature data from the EMC1212 and controlling the speed of one or more fans. Because the EMC1212 incorporates one internal and one external temperature diode, up to two separate thermal zones can be monitored and controlled. The host has the ability to compare measured temperature levels to preset limits and take the appropriate action when values are found to be out of limit.

### 3.1 Power Modes

The EMC1212 has two basic modes of operation that are controlled entirely by the host device.

#### Standby Mode:

The host can initiate standby mode by actively pulling the BBUS low. When the Host places the device in standby mode, the device immediately powers down to draw  $< 2\mu\text{A}$  of supply current. It will remain in this state until it is awakened by the host. If the host pulls the BBUS line low while temperature data is being clocked out, the device will not enter standby mode until completion of the data transfer. After entering standby mode, the device will remain in this mode until it is forced into active mode by the host. The transition from standby to active mode occurs when the host is no longer pulling the BBUS low.

#### Active Mode:

The host initiates active mode by enabling a weak pull up on the BBUS. In this mode, the EMC1212 continuously converts temperature data. During the time that the device is actively converting a temperature, the BBUS is in tri-state mode, and the Host places a weak pull-up on the bus to prevent it from floating. After a conversion is completed, the device automatically clocks out the data from the most recent conversion to the host. When the data packet has been entirely clocked out, the BBUS returns to tri-state mode, and the ADC begins converting the next temperature sample. While BBUS is in tri-state mode, the host can command the device to standby mode.

## 3.2 Temperature Monitor

Thermal diode temperature measurements are based on the change in forward bias voltage of a diode when operated at two or more different currents.

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

where:

$k$  = Boltzmann's constant

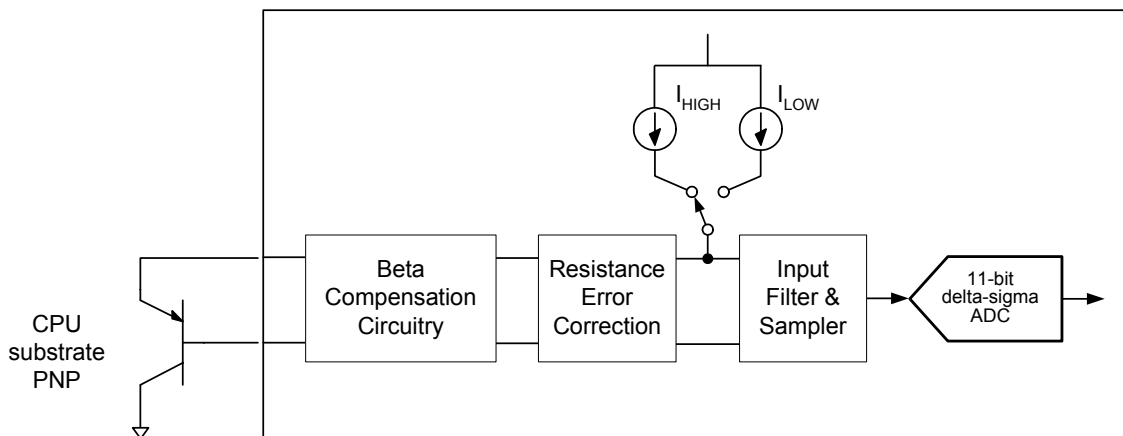
$T$  = absolute temperature in Kelvin

$q$  = electron charge

$\eta$  = diode ideality factor

As can be seen in this equation, the delta  $V_{BE}$  voltage is directly proportional to temperature. Figure 3.2 shows a block diagram of the temperature monitoring circuitry. The delta  $V_{BE}$  is first sampled at an effective rate of 3.125kHz and then measured by the internal 11 bit delta sigma ADC.

The advantages of this architecture over Nyquist rate FLASH or SAR converters are superb linearity and inherent noise immunity. The linearity can be directly attributed to the delta sigma ADC single bit comparator while the noise immunity is achieved by the 20.75ms integration time. The input bandwidth of the system is  $f_s/2048$ , this translates to 50Hz at a 100kHz clock frequency.



**Figure 3.2 Block Diagram of Temperature Monitoring**

The temperature data format is an offset 2's complement with a range of -64°C to +191.875°C as shown in Table 3.1.

**Table 3.1 EMC1212 Temperature Data Format**

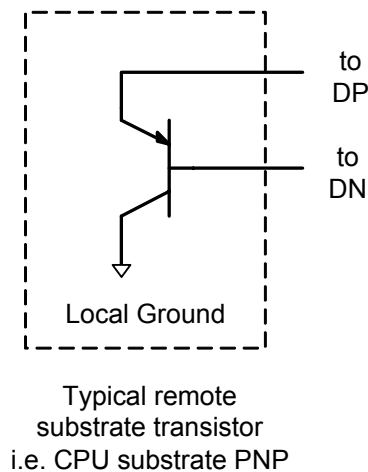
TEMPERATURE (°C)	2'S COMPLEMENT FORMAT	
	BINARY	HEX
Diode Fault or -64	100 0000 0000	400h
-63.875	100 0000 0001	401h
-63	100 0000 1000	408h
-1	110 1111 1000	6F8h
0	110 0000 0000	600h



**Table 3.1 EMC1212 Temperature Data Format (continued)**

TEMPERATURE (°C)	2'S COMPLEMENT FORMAT	
	BINARY	HEX
1	110 0000 1000	608h
63	111 1111 1000	7F8h
64	000 0000 0000	000h
65	000 0000 1000	008h
128	010 0000 0000	200h
191	011 1111 1000	3F8h
191.875	011 1111 1111	3FFh

The external diode supported by the EMC1212 must be connected as shown in [Figure 3.3](#). The EMC1202 available from SMSC will support other diode configurations.

**Figure 3.3 External Diode Configuration**

### 3.3 Resistance Error Correction

The EMC1212 includes resistance error correction implemented in the analog front end of the chip. Resistance error correction is an automatic feature that eliminates the need to characterize and compensate for the series resistance in the external diode lines.

When using a temperature sensor that does not include resistance error correction, voltage developed across the parasitic resistance in the remote 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.

## 3.4 Beta Compensation

The beta compensation circuitry corrects for beta variation in PNP substrate transistors used as thermal diodes. The EMC1212 is designed to work with 65nm processors manufactured by Intel.

For discrete transistors connected with collector to base as a diode, the beta is generally sufficiently high to make this relative beta variation very small (a variation of 10% from low current to high current when beta = 50 contributes approximately 0.25°C error at 100°C). However, for substrate transistors where the VBE junction is used for temperature measurement and the collector is tied to the substrate, the proportional beta variation causes more error (a variation of 10% from low current to high current when beta = 0.5 contributes approximately 8.25°C at 100°C).

Because the beta compensation circuit is designed to work with PNP substrate transistors, the EMC1212 should not be used with diode-connected transistors (such as the 2N3904) or CPUs that implement the thermal diode as a two-terminal diode. The beta compensation circuit is not present in the EMC1202 available from SMSC, and this device is an excellent companion to AMD CPUs.

## 3.5 Conversion Rate

The conversion rate is fixed to the value given in [Section 2.2](#), but conversions may be halted by periodically placing the device in standby as described in [Section 3.1, "Power Modes"](#).

## Chapter 4 Typical Operating Curves

To be determined based on characterization.

# Chapter 5 Package Drawing

Revision 1.1 (02-07-07)

12 DATASHEET

SMSC EMC1212

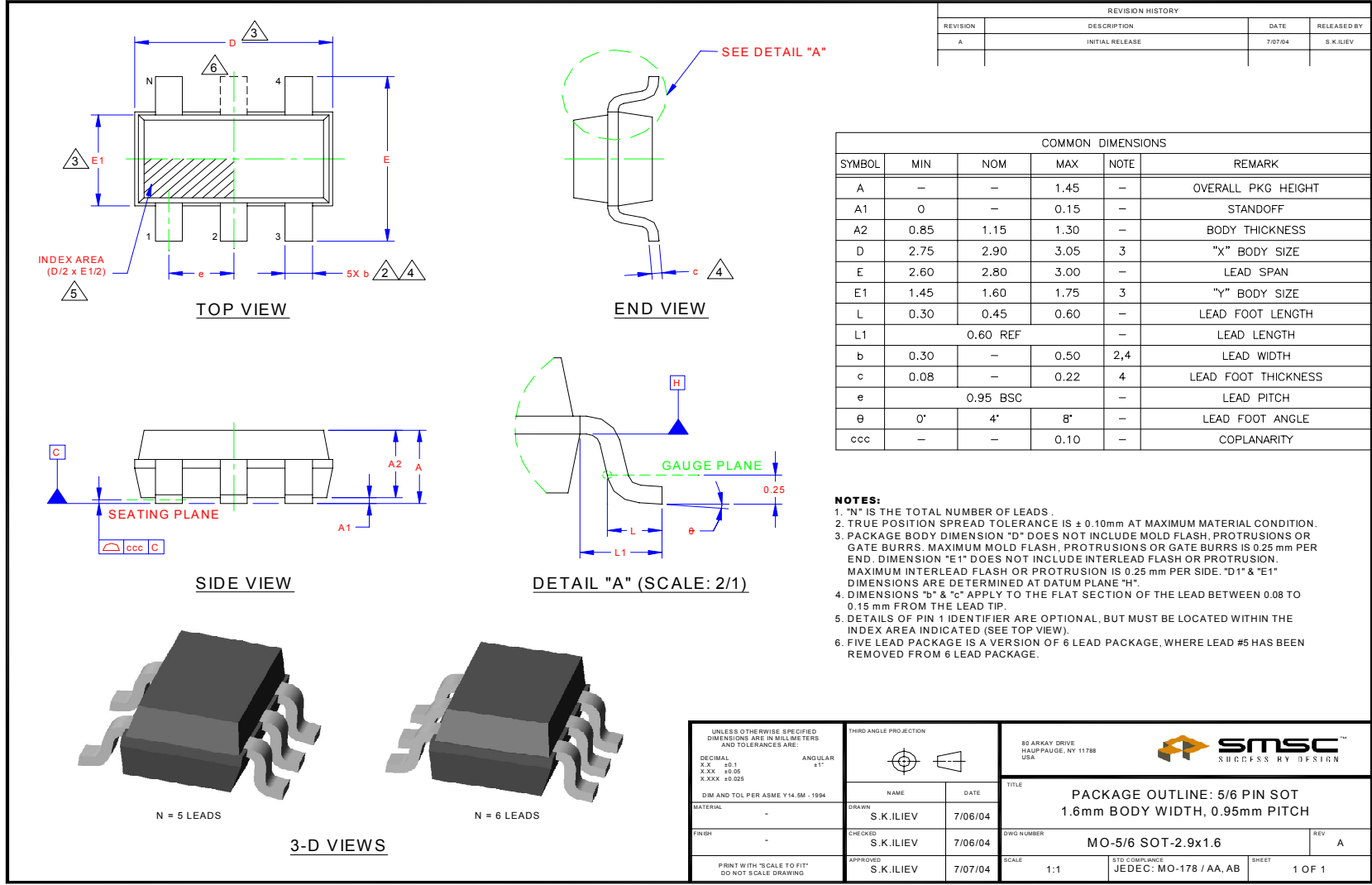


Figure 5.1 EMC1212 Package Outline and Parameters

**Datasheet**

## **5.1 Package Markings**

All devices will be marked on the top side with "212" and a lead free symbol. On the bottom, they will be marked with YYWW (2 digits for work week, 2 digits for year)