

## Triple/Quad Single-Wire Temp Sensor in MSOP-8 Using SMSC BudgetBus<sup>TM</sup> Sensor Interface

Datasheet

### General Description

The EMC1203 and EMC1204 are temperature sensors that communicate with a host over a single-wire SMSC BudgetBus<sup>TM</sup> Sensor Interface. The EMC1203 has an internal temperature sensor and monitors up to two remote diodes. An additional remote diode is added with the EMC1204 for a total of three remote zones, and both devices are in a small MSOP-8 package. 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 preserves battery life in portable applications. The internal 11-bit sigma delta temperature-to-digital converter provides superb linearity, high accuracy and excellent noise immunity.

| PART NUMBER | INTERNAL TEMPERATURE MONITOR | REMOTE TEMPERATURE MONITOR |
|-------------|------------------------------|----------------------------|
| EMC1203     | 1                            | 2                          |
| EMC1204     | 1                            | 3                          |

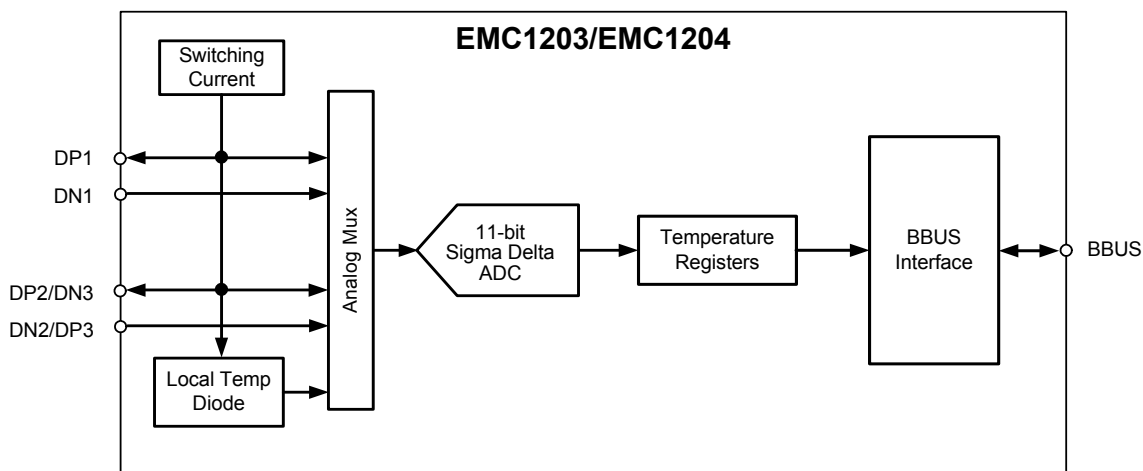
### Features

- Single-wire SMSC BudgetBus<sup>TM</sup> Sensor Interface
- Low Power, 3.0V to 3.6V Supply
  - < 50uA at 1 conversion per second
  - < 2.5uA in Standby
- External Temperature Sensor
  - Range -63.875° C to +191.875° C
  - 0.125° C resolution
  - ±1° C Accuracy 60° C to 100° C
  - Diode Fault Reporting
- Self Contained Internal Temperature Sensor
  - Range 0° C to +85° C
  - 0.125° C resolution
  - ±3° C Accuracy 0° C to 85° C
- MSOP-8 3x3mm packages; green, lead-free packages also available

### Applications

- Desktop Computers
- Notebook Computers
- Server Applications

### Simplified Block Diagram



**ORDER NUMBER(S):****EMC1203-ACZL-TR IN 8 PIN MSOP PACKAGE (GREEN, LEAD-FREE)****EMC1204-ACZL-TR IN 8 PIN MSOP PACKAGE (GREEN, LEAD-FREE)**

Reel size is 4,000 pieces.

Evaluation Board available upon request. (EVB-KBC1100)



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

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## Datasheet

# Chapter 1 Pin Configuration

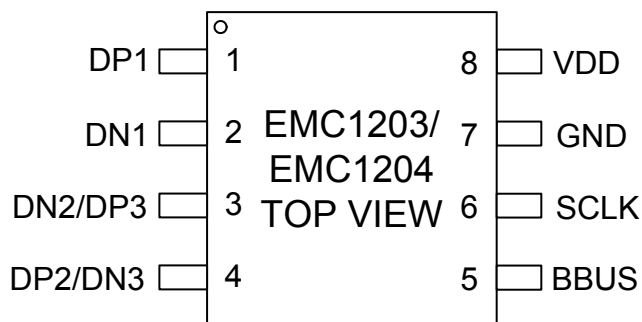


Figure 1.1 EMC1203 and EMC1204 Pin Configuration

## 1.1 Pin Description

Table 1.1 EMC1203 and EMC1204 Pin Description

| PIN     | PIN NO. | DESCRIPTION  |
|---------|---------|--|
| DP1     | 1       | Positive Analog Connection to External Temperature Diode 1   |
| DN1     | 2       | Negative Analog Connection to External Temperature Diode 1   |
| DN2/DP3 | 3       | Negative Analog Connection to External Temperature Diode 2<br>Positive Analog Connection to External Temperature Diode 3, EMC1204 only |
| DP2/DN3 | 4       | Positive Analog Connection to External Temperature Diode 2<br>Negative Analog Connection to External Temperature Diode 3, EMC1204 only |
| BBUS    | 5       | Serial Bus Interface to BBUS Host  |
| SCLK    | 6       | Normally GND, this pin may be configured to source a synchronous clock.  |
| GND     | 7       | Ground   |
| VDD     | 8       | Supply Voltage $V_{DD}$  |

## 1.2 Absolute Maximum Ratings

**Table 1.2 EMC1203 and EMC1204 Maximum Ratings**

| DESCRIPTION                                | RATING                         | UNIT |
|--|--------------------------------|------|
| Supply Voltage $V_{DD}$                    | -0.3 to 5.0                    | V    |
| Voltage on any other pin                   | -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 MSOP-8 |                                |      |
| Power Dissipation                          | TBD                            |      |
| Thermal Resistance(at 0 air flow)          | 109.6                          | °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.

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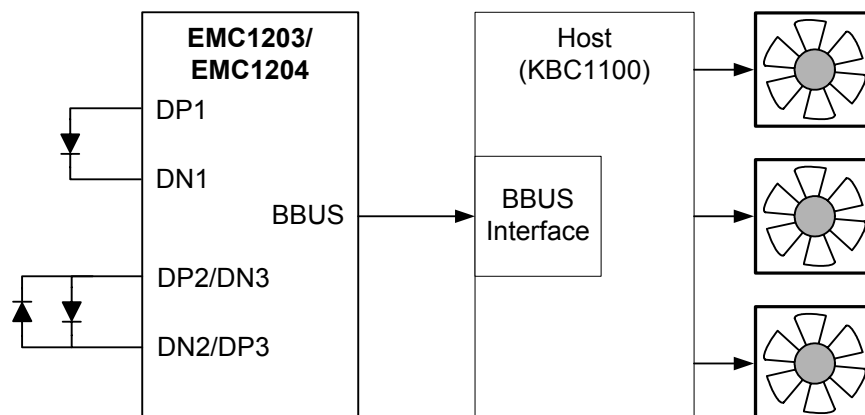
## Chapter 2 Electrical Characteristics

Table 2.1 Electrical Characteristics

| V <sub>DD</sub> =3.0V to 3.6V, T <sub>A</sub> = 0°C to +85°C, Typical values at T <sub>A</sub> = 27°C unless otherwise noted |                 |     |       |     |       |                                |
|--|-----------------|-----|-------|-----|-------|--------------------------------|
| PARAMETER  | SYMBOL          | MIN | TYP   | MAX | UNITS | CONDITIONS                     |
| <b>DC Power</b>  |                 |     |       |     |       |                                |
| Supply Voltage   | V <sub>DD</sub> | 3.0 | 3.3   | 3.6 | V     |                                |
| Average Operating Current  | I <sub>DD</sub> |     | 600   | 650 | μA    | Active mode (continuous)       |
|  | I <sub>PD</sub> |     | 1.8   | 2.5 | μA    | Standby mode                   |
| <b>Internal Temperature Measurement</b>  |                 |     |       |     |       |                                |
| Accuracy   |                 |     | ±1    | ±3  | °C    | 0°C ≤ T <sub>A</sub> ≤ 85°C    |
| <b>External Temperature Measurement</b>  |                 |     |       |     |       |                                |
| Temperature Accuracy   |                 |     |       |     |       |                                |
| Remote Diode 60°C to 100°C   |                 |     |       | ± 1 | °C    | 15°C ≤ T <sub>A</sub> ≤ 70°C   |
| Remote Diode 0°C to 125°C  |                 |     |       | ± 3 | °C    | 0°C ≤ T <sub>A</sub> ≤ 85°C    |
| Remote Diode 0°C to 125°C  |                 |     |       | TBD | °C    | -40°C ≤ T <sub>A</sub> ≤ 125°C |
| <b>ADC</b>   |                 |     |       |     |       |                                |
| Resolution   |                 |     | 0.125 |     | °C    |                                |
| Conversion Time per sensor   |                 |     | 20    |     | ms    |                                |

## Chapter 3 Product Description

The EMC1203 and EMC1204 are temperature sensors 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. [Figure 3.1, "System Overview"](#) shows a typical system overview:



**Figure 3.1 System Overview**

In cooperation with the host device, thermal management can be performed as shown in [Figure 3.1](#). Thermal management consists of the host acquiring the temperature data from the EMC1203 and EMC1204 controlling the speed of one or more fans. 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. The EMC1203 and the DP1/DN1 port of the EMC1204 are compatible with CPU substrate diodes.

Two separate temperature zones are monitored using only two pins on the EMC1204. This is accomplished using two anti-parallel diodes as shown on the pins DP2/DN3 and DN2/DP3 in [Figure 3.1](#). This technique maintains high accuracy while minimizing pin count and reducing board routing complexity. The anti-parallel diode architecture performs very well with diode connected transistors. It is not compatible with substrate transistors (sometimes called thermal diodes or on-chip sense junctions).

### 3.1 Temperature Monitors

Thermal diode temperature measurements are based on the change in forward bias voltage ( $\Delta V_{BE}$ ) of a diode when operated at two 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

The change in  $\Delta V_{BE}$  voltage is proportional to absolute temperature  $T$ .

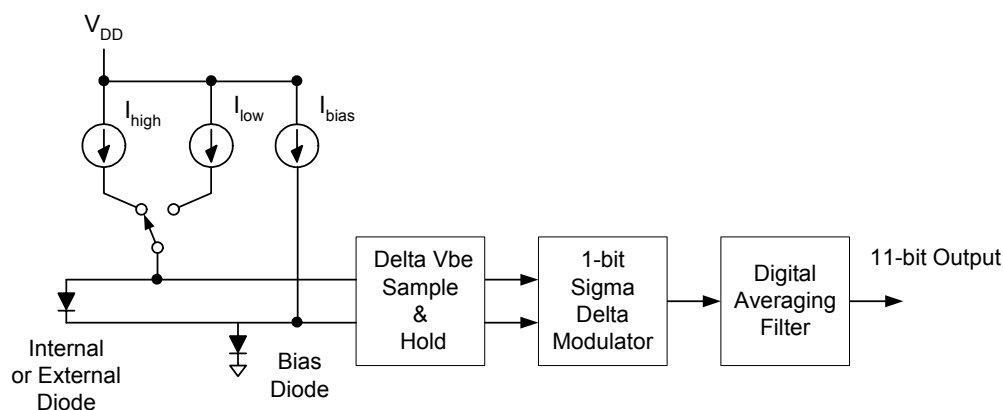
**Datasheet****Figure 3.2 Detailed Block Diagram of Temperature Monitor Architecture**

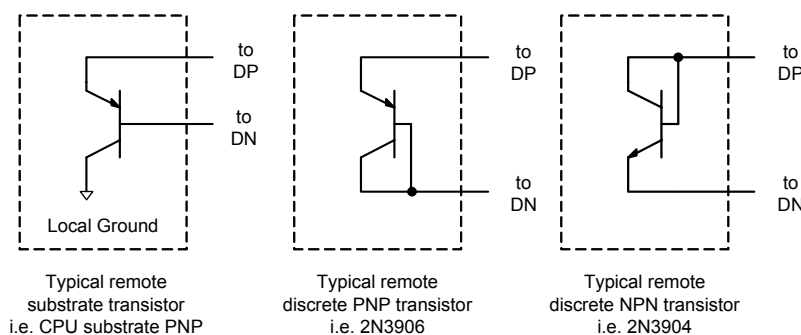
Figure 3.2 shows a detailed block diagram of the temperature measurement circuit. As shown, the EMC1203 and EMC1204 incorporate switched capacitor technology that samples the temperature diode voltage at two bias currents and holds the difference voltage. The sample frequency is 100kHz and the current levels  $I_{high}$  and  $I_{low}$  are 170uA and 10uA respectively.

The output of the switched capacitor sample and hold circuit interfaces to a single bit delta sigma analog to digital converter. This ADC runs at 100kHz sample frequency and its output is digitally filtered and averaged over 2048 samples effectively generating 11 bit accuracy.

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 digital averaging filter. The overall effective bandwidth of the system is  $f_s/2048$  which translates to a 50Hz bandwidth at 100kHz sample rate. Conversion time equals about 20ms per temperature monitor.

### 3.1.1 EMC1203 Temperature Monitoring

The EMC1203, incorporates one internal diode and can monitor two additional temperature zones with two external diodes. An internal analog multiplexer switches between the internal and external diodes. Total conversion time for one internal and two external temperature readings is about 60ms. The external diodes can be either a CPU substrate diode or a discrete diode connected transistor like the 2N3904 or 2N3906. External diode connected transistors examples are shown in Figure 3.3:

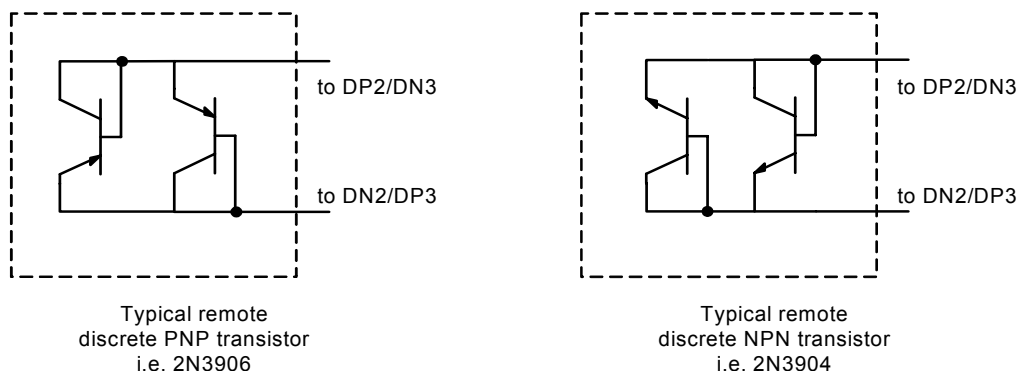
**Figure 3.3 EMC1203 External Diode Examples**

### 3.1.2 EMC1204 Temperature Monitoring

The EMC1204, incorporates one internal diode and can monitor three external diodes. Total conversion time for one internal and three external temperature reading is 80ms. An internal multiplexer switches between internal and external diodes. The external thermal diode connected to DP1 and DN1 can

either be a CPU substrate diode or a regular thermal diode-connected transistor. External diodes at DP2/DN3 and DN2/DP3 have to be connected in an anti-parallel fashion. Because of this, one diode will be forward biased while the other is reverse biased and therefore it is recommended to connect only discrete thermal diodes to these pins.

Do not use the anti-parallel interface (DP2/DN3 and DN2/DP3) to connect substrate transistors (sometimes called thermal diodes or on-chip sense junctions). External diode connected transistors examples are shown in [Figure 3.4](#)



**Figure 3.4 EMC1204 External Diode Examples**

## 3.2 SMSC BudgetBus™ Sensor Interface

The EMC1203 and EMC1204 series of temperature monitors communicate with a host controller, such as the KBC1100, through the SMSC BudgetBus™ Sensor Interface. The BBUS is a single wire serial communication protocol between the computer host and its peripheral devices. Please refer to the SMSC BudgetBus™ Sensor Interface Specification for detailed information about the modes of operation.

## 3.3 Power Modes

The EMC1203 and EMC1204 have two basic modes of operation:

### 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 < 2uA 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 EMC1203 and EMC1204 continuously convert 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.



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### 3.4 Temperature Data Format

Temperature readings are coded in 2's complement format with a -64°C offset. This format spans from -63.875°C to +191.875°C with 0.125°C resolution. A temperature measurement outside this range is reported as either -63.875°C or +191.875°C. The host must add 64°C to calculate the actual temperature. [Table 3.1](#) shows example temperature readings and the value that will be reported on the BBUS.

**Table 3.1 Temperature Data Format**

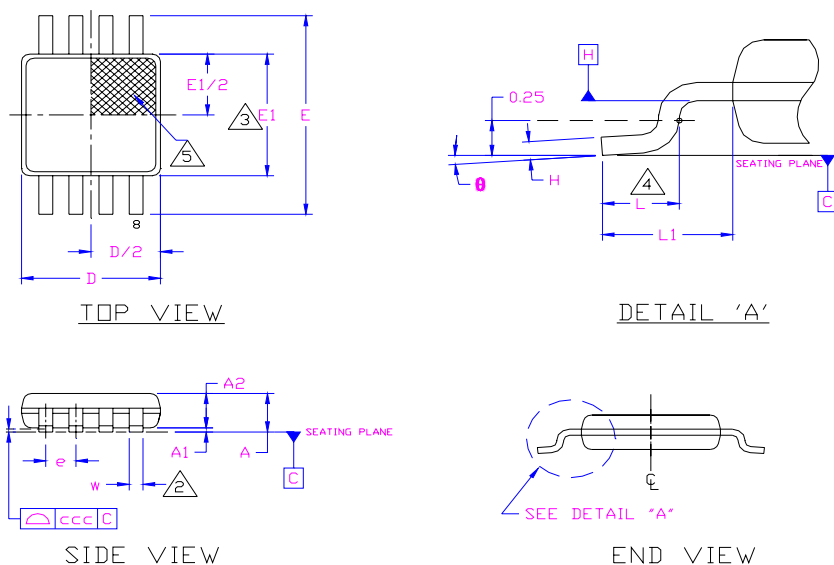
| ACTUAL TEMP.<br>(°C) | 2'S COMPLEMENT<br>OF -64°C OFFSET | HEX |
|----------------------|-----------------------------------|-----|
| Diode Fault          | 100 0000 0000                     | 400 |
| -63.875              | 100 0000 0001                     | 401 |
|                      |                                   |     |
| -63.000              | 100 0000 1000                     | 408 |
|                      |                                   |     |
| -1.000               | 101 1111 1000                     | 5F8 |
|                      |                                   |     |
| 0.000                | 110 0000 0000                     | 600 |
| +0.125               | 110 0000 0001                     | 601 |
|                      |                                   |     |
| +1.000               | 110 0000 1000                     | 608 |
|                      |                                   |     |

As shown in [Table 3.1](#), 400h is reserved for diode fault signaling which occurs when open or short conditions are detected between the external DP and DN pins.

### 3.5 Conversion Rate

The conversion rate can be controlled by the host. This is accomplished by periodically placing the device in standby as described in [Section 3.3](#).

## Chapter 4 Package Outline



**Figure 4.1 8-Pin MSOP Package Outline - 3x3mm Body 0.65mm Pitch**

**Table 4.1 8-Pin MSOP Package Parameters**

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

**Notes:**

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