

# Two Remote and One Local Temperature Sensors and 3/4 Fan Controllers with SMBus Interface

## Features

- Measures Two Remote and One Local Temperatures
- Adjustable Offset for Each Sensor via SMBus
- Accuracy: Remote  $\pm 1^{\circ}\text{C}$  ( $+20^{\circ}\text{C}$  to  $+80^{\circ}\text{C}$ )  
 $\pm 3^{\circ}\text{C}$  ( $-10^{\circ}\text{C}$  to  $+120^{\circ}\text{C}$ )
- +4.5V to +5.5V Supply Range
- Alert Signal for Diode Fault, Fan Fail, and Fan Out of Control
- Supports SMBus Alert Response
- Fan Drivers Using Linear Control Algorithm
- Closed Loop Speed Control and programmable 8 Bits Open Loop Voltage Control for Fan
- Wide speed control range for Fan, Accuracy within 2%, when  $\text{FANx\_SET\_CNT} > 50$
- Internal Current-limit and Over-temperature Protection for the Fan Controllers
- Build-In Inverters for Driving Crystal
- Optional Internal Clock Accuracy  $\pm 3\%$  from  $20^{\circ}\text{C}$  to  $80^{\circ}\text{C}$  at 5V VCC
- 20-Pin TSSOP Package

## Applications

- Projector, LCD TV, PDP TV
- Desktop and Notebook
- Central Office Computers
- Telecom Equipments
- Industrial Controls
- LAN Servers

## Ordering Information

| ORDER NUMBER | MARKING | TEMP. RANGE                                     | PACKAGE (Green) |
|--------------|---------|-------------------------------------------------|-----------------|
| G7931D51U    | G7931   | $-55^{\circ}\text{C}$ to $+125^{\circ}\text{C}$ | TSSOP-20        |
| G7932D51U    | G7932   | $-55^{\circ}\text{C}$ to $+125^{\circ}\text{C}$ | TSSOP-20        |

Note: D5: TSSOP-20

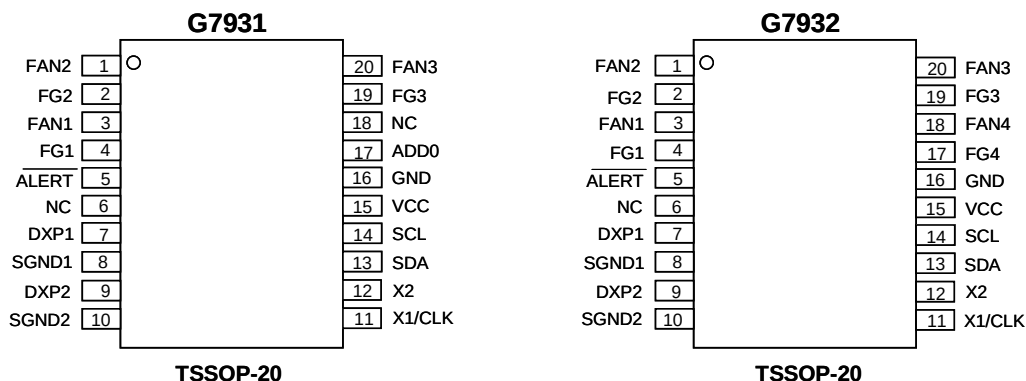
1: Bonding Code

U: Tape & Reel

Green : Lead Free / Halogen Free.

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## Pin Configuration



## General Description

The G7931/G7932 contains 3 precise digital thermometers, 3/4 fan controllers, fan failure detection.

The thermometers report the temperature of 2 remote sensors and 1 local sensor. The remote sensors are diode-connected transistors typically a low-cost, easily mounted 2N3904 NPN type or the diode built-in in CPU. Remote accuracy is  $\pm 1^{\circ}\text{C}$  for multiple transistor manufacturer. Local accuracy is  $\pm 3^{\circ}\text{C}$ . The G7931/G7932 also support offset adjust function via SMBus to fix the error due to different CPU diode or parasitic resistors.

The 2-wire serial interface accepts standard System Management Bus (SMBus™) Write Byte, Read Byte, Send Byte, and Receive Byte commands. The SMBus address is 72h for write and 73h for read for G7932. For G7931, ADD0 pin selects 3 different SMBus addresses. (see "SMBus Digital Interface" section)

G7931/G7932 contains 3/4 fan controllers which perform closed-loop and open-loop control. G7931/ G7932 determines the current fan speed based on the FG inputs and an externally supplied 32.768kHz clock. The driving ability is 5mA. G7931/G7932 also provides ALERT for fan fail and out of control event.

SMBus™ is a trademark of Intel Corp

## Absolute Maximum Ratings

VCC to GND. . . . . -0.3V to +6V  
 DXP to SGND . . . . . -0.3V to VCC + 0.3V  
 SMBCLK, SMBDATA,  $\overline{\text{ALERT}}$ , FG1, FG2, FG3, FG4,  
 SMBDATA,  $\overline{\text{ALERT}}$  Current. . . . . -1mA to +50mA  
 ESD Protection (human body model) . . . . . 2000V  
 Continuous Power Dissipation ( $T_A = +70^\circ\text{C}$ )  
 TSSOP-20(derate 8.0mW/ $^\circ\text{C}$  above  $+70^\circ\text{C}$ ) . . 720mW

Thermal Resistance Junction to Ambient, ( $\theta_{JA}$ )  
 TSSOP-20 . . . . . 125 $^\circ\text{C}/\text{W}$   
 Thermal Resistance Junction to Case, ( $\theta_{JC}$ )  
 TSSOP-20 . . . . . 30 $^\circ\text{C}/\text{W}$   
 Operating Temperature Range . . . . . -55 $^\circ\text{C}$  to +125 $^\circ\text{C}$   
 Junction Temperature. . . . . +150 $^\circ\text{C}$   
 Storage temperature Range. . . . . -65 $^\circ\text{C}$  to +165 $^\circ\text{C}$   
 Reflow Temperature (soldering, 10sec) . . . . . 260 $^\circ\text{C}$

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## Electrical Characteristics

( $V_{CC} = +5\text{V}$ ,  $T_A = 60^\circ\text{C}$ , unless otherwise noted.)

| PARAMETER                                          | CONDITION                                                                                    |                                               | MIN  | TYP    | MAX | UNIT |
|----------------------------------------------------|----------------------------------------------------------------------------------------------|-----------------------------------------------|------|--------|-----|------|
| Supply-Voltage Range                               |                                                                                              |                                               | 4.5  | 5      | 5.5 | V    |
| Temperature Sensor                                 |                                                                                              |                                               |      |        |     |      |
| Remote Temperature Resolution (Note1)              |                                                                                              |                                               | ---  | 0.125  | --- | °C   |
| Temperature Error, Remote Diode<br>(Notes 2 and 3) | T <sub>R</sub> = 20°C to +80°C                                                               |                                               | -1   | ---    | 1   | °C   |
|                                                    | T <sub>R</sub> = -10°C to +120°C                                                             |                                               | -3   | ---    | 3   |      |
| Local Temperature Resolution (Note1)               |                                                                                              |                                               | ---  | 1      | --- | °C   |
| Temperature Error, Internal Diode<br>(Notes 2 )    | T <sub>R</sub> = 20°C to +80°C                                                               |                                               | -3   | ---    | 3   | °C   |
|                                                    | T <sub>R</sub> = -10°C to +120°C                                                             |                                               | -5   | ---    | 5   |      |
| Under-voltage Lockout Threshold                    | V <sub>CC</sub> input, disables A/D conversion, rising edge                                  |                                               | ---  | 2.7    | --- | V    |
| Under-voltage Lockout Hysteresis                   |                                                                                              |                                               | ---  | 1      | --- | mV   |
| Power-On Reset Threshold                           | V <sub>CC</sub> , falling edge                                                               |                                               | ---  | 2.2    | --- | V    |
| POR Threshold Hysteresis                           |                                                                                              |                                               | ---  | 1      | --- | mV   |
| Standby Supply Current                             | Logic inputs forced to V <sub>CC</sub> or GND                                                | Hardware or software standby, SMBCLK at 10kHz | ---  | 750    | --- | μA   |
| Average Operating Supply Current                   | Auto-convert mode, average measured over 4sec. Logic inputs forced to V <sub>CC</sub> or GND | 0.5 conv/sec                                  | ---  | 1000   | --- | μA   |
| Conversion Time                                    | From stop bit to conversion complete (all channels)                                          |                                               | ---  | 300    | --- | ms   |
| Conversion Rate Timing Error                       | Auto-convert mode                                                                            |                                               | -25  | ---    | 25  | %    |
| Remote-Diode Source Current                        | DXP forced to 1.5V                                                                           | High level                                    | ---  | 210    | --- | μA   |
|                                                    |                                                                                              | Low level                                     | ---  | 13.2   | --- |      |
| Fan Controller                                     |                                                                                              |                                               |      |        |     |      |
| Fan High Side Driver MOSFET on Resistance          | SETFAN=FFh, I <sub>FAN1</sub> =5mA                                                           |                                               | ---  | 40     | --- | Ω    |
| Fan Driver Current Limit                           | SETFAN=FFh                                                                                   |                                               | ---  | 20     | --- | mA   |
| Fan Output Drive Range                             | High side saturation voltage = 0.1V<br>Lowside saturation voltage =0.01V                     |                                               | -2.0 | ---    | 2.0 | mA   |
| Fan Open Loop Output Differential Nonlinearity     | V <sub>CC</sub> =5V, I <sub>FAN</sub> =Without Load                                          |                                               | -1   | ---    | 1   | LSB  |
| Fan Open Loop Output Nonlinearity                  |                                                                                              |                                               | -1   | ---    | 1   | LSB  |
| Fan Open Loop Output “code 1” Error                |                                                                                              |                                               | -2   | ---    | 2   | LSB  |
| Fan Open Loop Output Full Scale Error              |                                                                                              |                                               | -2   | ---    | 2   | LSB  |
| CLK pin Input Clock Frequency                      | CLK                                                                                          |                                               | ---  | 32.768 | --- | kHz  |
| Internal Clock Frequency                           | 20°C to 80°C, V <sub>CC</sub> =5V                                                            |                                               | -3%  | 32768  | +3% | Hz   |
| FG Input Positive-going Threshold Voltage          | V <sub>CC</sub> =5V                                                                          |                                               | ---  | 2.3    | --- | V    |
| FG input Negative-going threshold voltage          | V <sub>CC</sub> =5V                                                                          |                                               | ---  | 1.3    | --- | V    |

**Electrical Characteristics (continued)**

 (V<sub>CC</sub> = + 5V, T<sub>A</sub> = 60°C, unless otherwise noted.)

| PARAMETER                                       | CONDITION                                                     | MIN | TYP | MAX  | UNIT |
|-------------------------------------------------|---------------------------------------------------------------|-----|-----|------|------|
| <b>SMBus Interface</b>                          |                                                               |     |     |      |      |
| Logic Input High Voltage                        | SMBCLK, SMBDATA; V <sub>CC</sub> = 4.5V to 5.5V               | 2.4 | --- | ---  | V    |
| Logic Input Low Voltage                         | SMBCLK, SMBDATA; V <sub>CC</sub> = 4.5V to 5.5V               | --- | --- | 0.8  | V    |
| ALERT Logic Output Low Current                  | ALERT, SMBDATA forced to 0.4V                                 | 6   | --- | ---  | mA   |
| ALERT Output High Leakage Current               | ALERT forced to 5.5V                                          | --- | 1   | ---  | μA   |
| Logic Input Current                             | Logic inputs forced to V <sub>CC</sub> or GND                 | -2  | --- | 2    | μA   |
| SMBus Input Capacitance                         | SMBCLK, SMBDATA                                               | --- | 5   | ---  | pF   |
| SMBus Clock Frequency                           |                                                               | 100 | --- | 400k | Hz   |
| SMBCLK Clock Low Time                           | t <sub>LOW</sub> , 10% to 10% points                          | 4.7 | --- | ---  | μs   |
| SMBCLK Clock High Time                          | t <sub>HIGH</sub> , 90% to 90% points                         | 4   | --- | ---  | μs   |
| SMBus Start-Condition Setup Time                |                                                               | 4.7 | -   | ---  | μs   |
| SMBus Repeated Start-Condition Setup Time       | t <sub>SU: STA</sub> , 90% to 90% points                      | 500 | --- | ---  | μs   |
| SMBus Start-Condition Hold Time                 | t <sub>HD: STA</sub> , 10% of SMBDATA to 90% of SMBCLK        | 4   | --- | ---  | μs   |
| SMBus Start-Condition Setup Time                | t <sub>SD: STO</sub> , 90% of SMBDATA to 10% of SMBDATA       | 4   | --- | ---  | μs   |
| SMBus Data Valid to SMBCLK Rising-Edge Time     | t <sub>SU: DAT</sub> , 10% or 90% of SMBDATA to 10% of SMBCLK | 800 | --- | ---  | ns   |
| SMBus Data-Hold Time                            | t <sub>HD: DAT</sub>                                          | 0   | --- | ---  | μs   |
| SMBCLK Falling Edge to SMBus Data-Valid Time    | Master clocking in data                                       | --- | --- | 1    | μs   |
| Register Reset Time by SMBus Reset (OE) Command | SMBCLK clock rate 100kHz, 40 cycles                           | --- | 93n | 400μ | s    |
| SMBDATA Output Voltage Low Level                | SMBDATA V <sub>OL</sub> , I <sub>OL</sub> = 3mA               | --- | --- | 0.4  | V    |

Note 1: Guaranteed but not 100% tested.

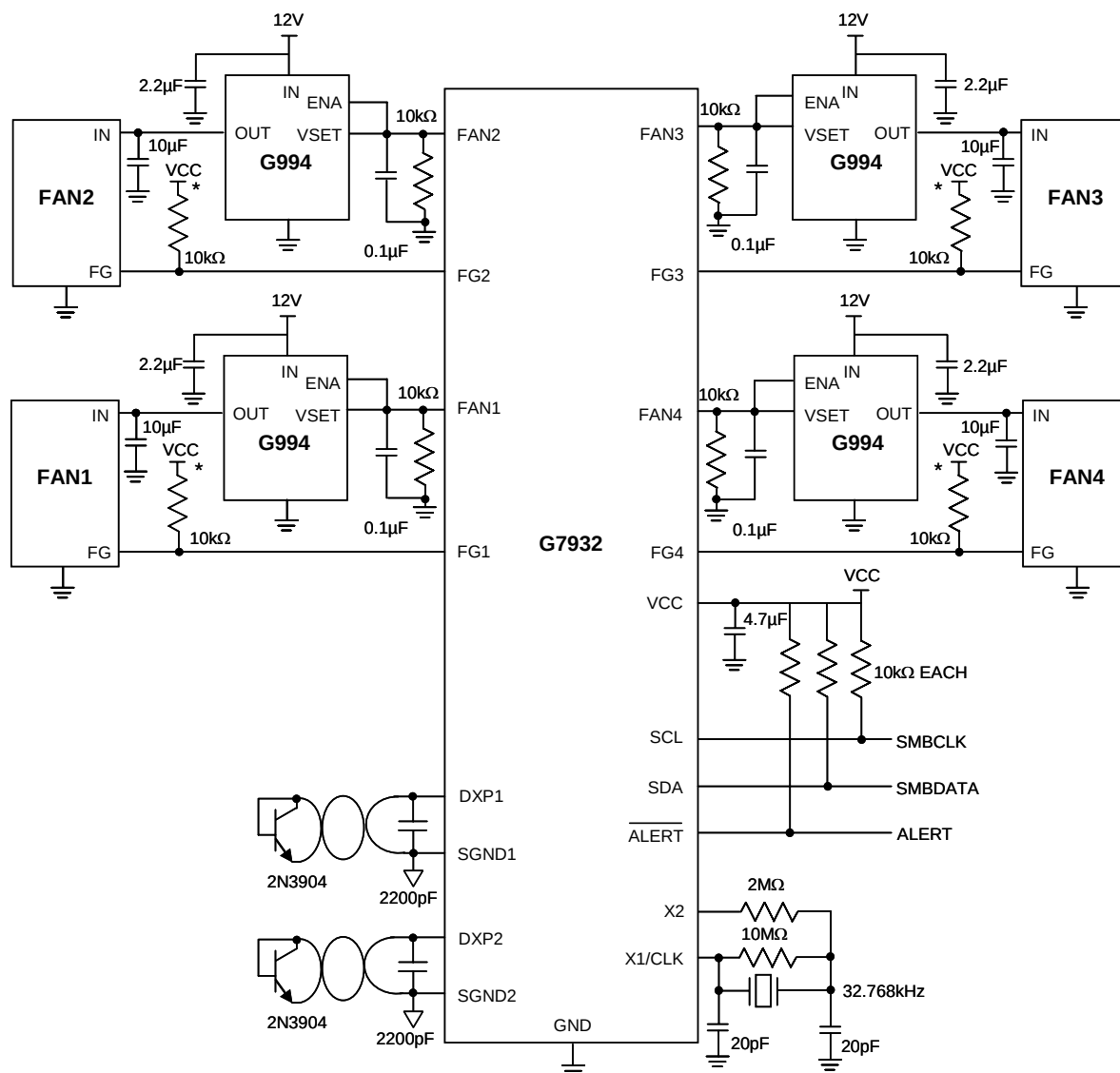
Note 2: Quantization error is not included in specifications for temperature accuracy.

Note3: A remote diode is any diode-connected transistor from Table1. TR is the junction temperature of the remote diode. See Remote Diode Selection for remote diode forward voltage requirements.

**Pin Description**

| PIN   |       | NAME   | FUNCTION                                                                                                                                                                                                                               |
|-------|-------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| G7931 | G7932 |        |                                                                                                                                                                                                                                        |
| 1     | 1     | FAN2   | DAC2 output connected to fan driver circuit.                                                                                                                                                                                           |
| 2     | 2     | FG2    | Fan2 pulse input.                                                                                                                                                                                                                      |
| 3     | 3     | FAN1   | DAC1 output connected to fan driver circuit.                                                                                                                                                                                           |
| 4     | 4     | FG1    | Fan1 pulse input.                                                                                                                                                                                                                      |
| 5     | 5     | ALERT  | SMBus Alert (interrupt) Output, open drain.                                                                                                                                                                                            |
| 6     | 6     | NC     | No Connection.                                                                                                                                                                                                                         |
| 7     | 7     | DXP1   | Combined Current Source and A/D Positive Input for remote-diode channel 1. Do not leave DXP1 floating; tie DXP1 to SGND1 if no remote diode on channel 1 is used. Place a 2200pF capacitor between DXP1 and SGND1 for noise filtering. |
| 8     | 8     | SGND1  | Combined Current Sink, A/D Negative Input and analog ground. The SGND1 should be connected together as close as possible to the IC and connected to a clear ground.                                                                    |
| 9     | 9     | DXP2   | Combined Current Source and A/D Positive Input for remote-diode channel 2. Do not leave DXP2 floating; tie DXP2 to SGND2 if no remote diode on channel 1 is used. Place a 2200pF capacitor between DXP2 and SGND2 for noise filtering. |
| 10    | 10    | SGND2  | Combined Current Sink, A/D Negative Input and analog ground. The SGND2 should be connected together as close as possible to the IC and connected to a clear ground.                                                                    |
| 11    | 11    | X1/CLK | The input terminal of the built-in inverter for driving crystal.                                                                                                                                                                       |
| 12    | 12    | X2     | The output terminal of the built-in inverter for driving crystal.                                                                                                                                                                      |
| 13    | 13    | SDA    | SMBus Serial-Data input/output, open drain.                                                                                                                                                                                            |
| 14    | 14    | SCL    | SMBus Serial-Clock Input.                                                                                                                                                                                                              |
| 15    | 15    | VCC    | Supply voltage input for digital part. Bypass to GND with a 4.7μF capacitor.                                                                                                                                                           |
| 16    | 16    | GND    | Digital Ground.                                                                                                                                                                                                                        |
| 17    | ---   | ADD0   | SMBus slave address select pin.                                                                                                                                                                                                        |
| ---   | 17    | FG4    | Fan4 pulse input.                                                                                                                                                                                                                      |
| ---   | 18    | FAN4   | DAC4 output connected to fan driver circuit.                                                                                                                                                                                           |
| 18    | ---   | NC     | No Connection.                                                                                                                                                                                                                         |
| 19    | 19    | FG3    | Fan3 pulse input.                                                                                                                                                                                                                      |
| 20    | 20    | FAN3   | DAC3 output connected to fan driver circuit.                                                                                                                                                                                           |

**Typical Operating Circuit**



\* Note: If FG is open-drain/open-collector output, add 10kΩ pull-high resistor.

## Detailed Description

The G7931/2 consists of 2 remote 1 local temperature sensors and 3/4 fan controllers with SMBus serial interface (Figure 1).

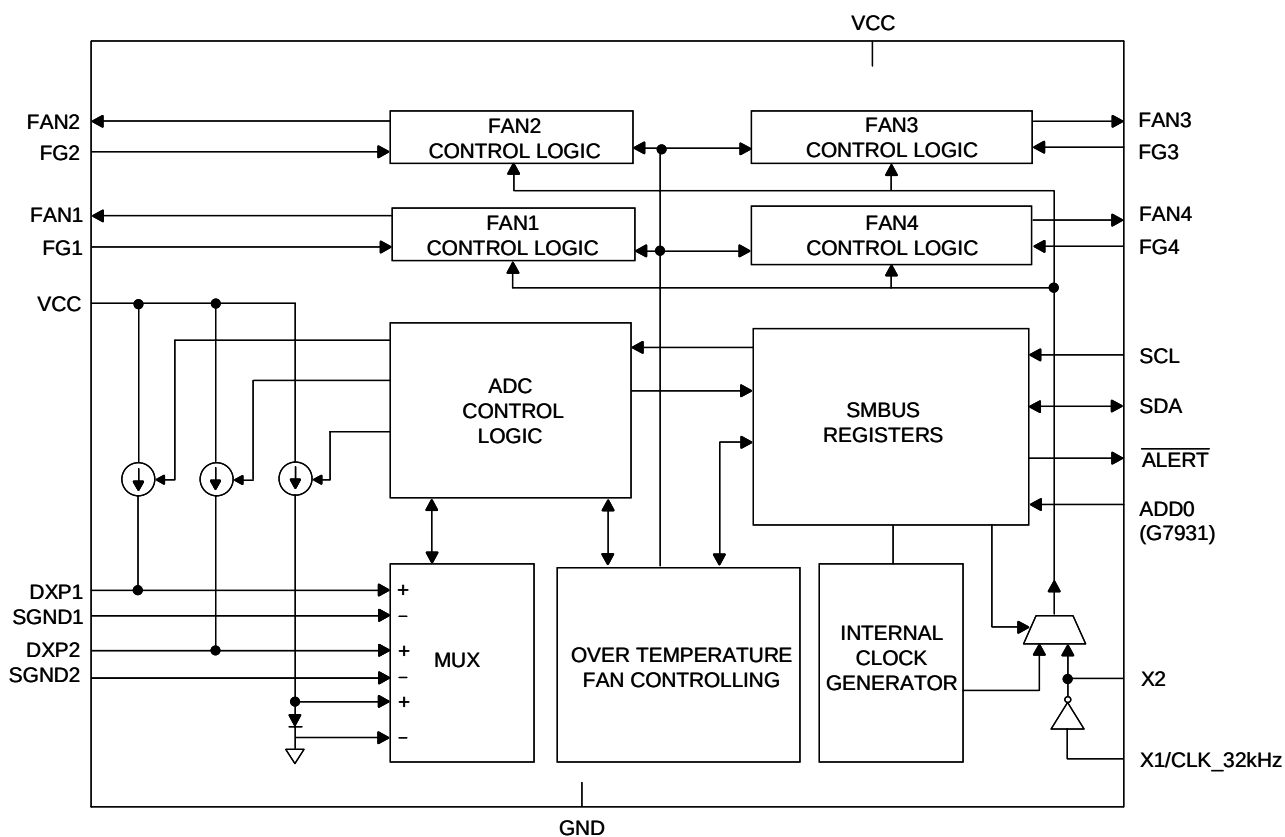


Figure 1. Functional Diagram

### Thermal Sensors

Thermal diodes can be a 2N3904 NPN type or the diode built-in in CPU. Connect a thermal diode from DXP to SGND, and tie SGND to a clear ground. A multiplexer automatically steers bias currents through the 2 remote and 1 Local diodes, measures their forward voltage, and computes their temperatures. If one of the three channels is not used, the device still performs three measurements, and the users can simply ignore the result of the unused channel. Tie the DXP to SGND rather than leaving the pin floating if the corresponding channel is not used. The diode selection and PCB layout guides are stated in application notes.

The accuracies of thermal sensors is  $\pm 1^{\circ}\text{C}$  ( $+20^{\circ}\text{C}$  to  $80^{\circ}\text{C}$ ). Excess resistance in series with the remote diode cause about  $+0.6^{\circ}\text{C}$  error per ohm. Namely,  $240\mu\text{V}$  of offset voltage forces on DXP-SGND, then causes about  $1^{\circ}\text{C}$  error.

### Data Format of Temperature Outputs

The format of temperature data format is 11 bits plus sign in two's-complement form, with each data bit representing  $0.125^{\circ}\text{C}$  (Table1, Table2). The MSB 8 bits can be read via SMBus by commands 00h (sensor 2), 01h (sensor 1), and 05h (local sensor). The extended bits for sensor 1 are data bit 7~bit 5 read by command 06h, and for sensor 2 are data bit 4~bit 2 of command 06h respectively.

**Table 1. Temperature Data Format (Two's-Complement)**

| TEMP.<br>( $^{\circ}\text{C}$ ) | DIGITAL OUTPUT |     |      |     |
|---------------------------------|----------------|-----|------|-----|
|                                 | DATA BITS      |     |      |     |
|                                 | SIGN           | MSB | LSB  | EXT |
| +127.875                        | 0              | 111 | 1111 | 111 |
| +126.375                        | 0              | 111 | 1110 | 011 |
| +25.5                           | 0              | 001 | 1001 | 100 |
| +1.75                           | 0              | 000 | 0001 | 110 |
| +0.5                            | 0              | 000 | 0000 | 100 |
| +0.125                          | 0              | 000 | 0000 | 001 |
| -0.125                          | 1              | 111 | 1111 | 111 |
| -1.125                          | 1              | 111 | 1110 | 111 |
| -25.5                           | 1              | 110 | 0110 | 100 |
| -55.25                          | 1              | 100 | 1000 | 110 |
| -65.000                         | 1              | 011 | 1111 | 000 |

**Table 2. Extended Temperature Data Format**

| EXTENDED RESOLUTION     | DATA BITS |
|-------------------------|-----------|
| $0.000^{\circ}\text{C}$ | 000       |
| $0.125^{\circ}\text{C}$ | 001       |
| $0.250^{\circ}\text{C}$ | 010       |
| $0.375^{\circ}\text{C}$ | 011       |
| $0.500^{\circ}\text{C}$ | 100       |
| $0.625^{\circ}\text{C}$ | 101       |
| $0.750^{\circ}\text{C}$ | 110       |
| $0.875^{\circ}\text{C}$ | 111       |

### Thermal Sensors Conversion Sequence

If a Start command is written (or generated automatically in the free-running auto-convert mode), 3 channels are converted, and the 3 results are available after the end of conversion. A BUSY status in the bit 7 of status byte read by command 02h shows that the device is actually performing a new conversion; however, even if the ADC is busy, the results of the previous conversion are always available.

Free-running conversion rate is from 0.5Hz to 4Hz controlled by data bits 5 ~ bits 4 of command 04h (Table3). Default is set to 1Hz. To reduces supply current, set the conversion rate to 0.5Hz or set to standby mode and using one-shot command.

One-shot command 0Fh initiates a single conversion during the stop conversion period.

**Table 3. Conversion-Rate Control Byte**

| DATA | CONVERSION RATE (Hz) |
|------|----------------------|
| 00   | 0.5                  |
| 01   | 1                    |
| 10   | 2                    |
| 11   | 4                    |

### Temperature Offset Adjustment

Data bit 3~bit 0 of command 07h, 08h are for fixing the temperature offsets from parasitic resistors or diode variation of the three sensors. The data format is two's-complement form. (Table 4)

**Table 4. Code Offset Data Format**

| OFFSET | DATA BITS |
|--------|-----------|
| +3.5°C | 0111      |
| +3°C   | 0110      |
| +2.5°C | 0101      |
| +2.0°C | 0100      |
| +1.5°C | 0011      |
| +1.0°C | 0010      |
| +0.5°C | 0001      |
| 0°C    | 0000      |
| -0.5°C | 1111      |
| -1.0°C | 1110      |
| -1.5°C | 1101      |
| -2.0°C | 1100      |
| -2.5°C | 1011      |
| -3.0°C | 1010      |
| -3.5°C | 1001      |
| -4°C   | 1000      |

### Diode Fault and Diode Short Detection

At the beginning of each conversion, diode fault detector at DXP detects whether the remote diodes are in open condition or not? If DXP rises above VCC-1V (typical) due to the diode current source, diode fault condition occurs. ALERT pin outputs low and remote temperature reading doesn't update if the corresponding diode is open. Note that the diode fault isn't checked until a conversion is initiated, so immediately after power-on reset no fault is present even if the diode path is broken. The diode fault condition can be read by status0 read (command 02h). Bit 6~bit5 are corresponding to the diode fault events of sensor 2, sensor 1.

G7931/2 contains a diode short detector. If DXP falls below 0.1V at the beginning of the conversion, the temperature reading of the channel is -128°C.

### FAN Controller

The FAN controller performs both open-loop or closed-loop control mode. The control mode is selected by setting bit 1 of configuration registers. Default bit 1 is high indicates close-loop mode.

In open-loop control mode, FAN outputs a fixed voltage. 8 bits FANx\_SET\_DAC registers (command 13h/23h/33h/43h) set the output voltage. The formula of output voltage is

$$\frac{V_{cc}}{5} + (FANx\_SET\_DAC) \times \frac{1}{256} \times \frac{4}{5} V_{cc}$$

If FANx\_SET\_DAC=0, fan will turn off, FANx=0V  
 In closed-loop control mode, FAN controller performs fan revolution speed control. Users set 8 bits FANx\_SET\_CNT registers (command 10h/20h/30h/40h) and FAN\_CMD2 registers (data bit 3, bit 2 of command 14h/24h/34h/44h, Table 7) to change the target fan RPM. CPR is the pulse counts per revolution, the input FG. FANx\_SET\_CNT set the counting number of CLK pin 32.768kHz clock input between the two falling edges of FG. Read 8 bits ACT\_CNT registers (command 12h/22h/32h/42h) to get the actual FAN RPM. The formula of RPM versus FG\_CLK\_ID, FG\_GEAR\_MODE, FG\_PLS\_ID and SET\_CNT (ACT\_CNT) is

FG\_CLK\_ID: FG counting frequency

FG\_GEAR\_MODE: High speed fan setting factor

FG\_PLS\_ID: FG pulses number per revolution

Before setting the FANx\_SET\_CNT, make sure the

FG\_PLS\_ID is fit the fan characteristic. Default

FG\_PLS\_ID data bits are 00b for 2 pules/ revolution.

FANx\_SET\_CNT (FANx\_ACT\_CNT) = N: Count Number

If FG\_GEAR\_MODE = 0 (default)

FG\_CLK\_ID = 0 => N = 491520 / rpm

FG\_CLK\_ID = 1 => N = 245760 / rpm

FG\_CLK\_ID = 2 => N = 122880 / rpm

Some FANx\_SET\_CNT (x=1,2,3,4)selected count number are listed below. (Table 5.)

**Table 5. RPM vs. Count Number at Different FG\_CLK\_ID Data Bits**

| RPM   | CLK_ID=00 | CLK_ID=01 | CLK_ID=10 |
|-------|-----------|-----------|-----------|
| 500   | N/A       | N/A       | 246       |
| 1000  | N/A       | 246       | 123       |
| 2000  | 246       | 123       | 61        |
| 3000  | 164       | 82        | 41        |
| 4000  | 123       | 61        | 31        |
| 5000  | 98        | 49        | 25        |
| 6000  | 82        | 41        | 20        |
| 7000  | 70        | 35        | 18        |
| 7680  | 64        | 32        | 16        |
| 8000  | 61        | 31        | N/A       |
| 9000  | 55        | 27        | N/A       |
| 10000 | 49        | 25        | N/A       |
| 15360 | 32        | 16        | N/A       |
| 20000 | 25        | N/A       | N/A       |
| 30000 | 16        | N/A       | N/A       |

To stop the fan, program the fan speed register to 255. This RPM control accuracy is within 2%, when FANx\_SET\_CNT > 50.



**Table 6. Pulse Counts Per Revolution**

| PULSE COUNTS | DATA BITS |
|--------------|-----------|
| 2            | 00        |
| 4            | 01        |
| 8            | 10        |
| 2            | 11        |

## Fan Gear-Mode

According to high rotation speed type fan, the FG counting number is smaller than lower speed one and the speed controlling accuracy is less than 2% when rotation speed is over 9500rpm(FG\_CLK\_ID=0). To increase the accuracy of the speed controlling we designed the Gear-Mode to solve this problem.

**Table 7. RPM vs. Count Number at Different FG\_GEAR\_MODE Data Bits**

| RPM   | FG_GEAR_MODE =00 | FG_GEAR_MODE =01 | FG_GEAR_MODE =10 |
|-------|------------------|------------------|------------------|
| 2000  | 246              | N/A              | N/A              |
| 3000  | 164              | N/A              | N/A              |
| 4000  | 123              | 246              | N/A              |
| 5000  | 98               | 197              | N/A              |
| 6000  | 82               | 164              | N/A              |
| 7000  | 70               | 140              | N/A              |
| 8000  | 61               | 123              | 246              |
| 9000  | 55               | 109              | 218              |
| 10000 | 49               | 98               | 197              |
| 20000 | 25               | 49               | 98               |
| 30000 | 16               | 32               | 66               |

If FG\_CLK\_ID = 0 (default)

FG\_GEAR\_MODE = 0 => N = 491520 / rpm

FG\_GEAR\_MODE = 1 => N = 983040 / rpm

FG\_GEAR\_MODE = 2 => N = 1966080 / rpm

Some FANx\_SET\_CNT (x=1,2,3,4) selected count number are listed in Table 7.

## Fan Start up Voltage Setting

To reduce the fan start up acoustic noise and fit the fan start up voltage spec request, G7931/2 provide a register can select 4 kind of start up voltage. User set FANx\_CMD2 register data bit1 and bit0 to determine the start up voltage.(Table 8.)

**Table 8. Fan Start Up Voltage Vs. Code**

| Start Up Voltage | DATA BITS |
|------------------|-----------|
| 1.0V(Code=0)     | 00        |
| 1.5V(Code=32)    | 01        |
| 2.0V(Code=64)    | 10        |
| 2.5V(Code=96)    | 11        |

## Internal 32768Hz Clock for Counting FG

The internal 32768Hz clock is used to counting FG pulses from the fans to indicate the fan rotation speed.

The internal clock is activated by setting CONFIG [2] register to logic 1. It is better to wire the input pin, X1, to logic 0 when using internal clock.

The internal clock is designed to have  $\pm 3\%$  frequency accuracy form 20°C to 80°C at 5V VCC.

The default value of CONFIG [2] is logic 0. It means not using internal clock. At this setting, the internal inverter between pin X1 and pin X2 can be used as the inverting stage of the external crystal oscillator circuit.

### Fan Protection and Fan Fail Detections

There are fan fail detection circuits for the 3/4 fans. Setting bit 7 of FANx\_CMD1 registers high to activate the detection of fan failure. G7931/2 defines fan failure as no transition on FG pin for about 0.7sec if FANx\_SET\_DAC is not set to 00h in open-loop control mode (or FANx\_SET\_CNT is not set to FFh in closed-loop control mode). Bit 7~ bit0 of status1 registers record the fan fail event of FAN4, FAN3, FAN2, FAN1. If fan failure events occur, ALERT pin goes low. To disable the fan-failure detection, set bit 7, of FANx\_CMD1 registers low.

In closed-loop control mode, if FAN actual RPM is below -20% or over 32% of the programmed value for over 6 seconds (typical), bit 6/4/2/0 in status register is set low to indicate FANx out of control event. ALERT pin also goes low if this condition occurs. To disable the out of control detection, set bit 6 in FANx\_CMD1 registers low.

**Table 9. FAN closed-loop control mode RPM high-low limit**

| RPM   | low limit% | high limit% |
|-------|------------|-------------|
| 2000  | -19.9479   | 32.84324    |
| 3000  | -18.08     | 28          |
| 4000  | -19.6863   | 32.12903    |
| 5000  | -19.423    | 32.84324    |
| 6000  | -19.6863   | 32.12903    |
| 7000  | -19.2906   | 32.48518    |
| 8000  | -19.1579   | 33.56522    |
| 9000  | -19.6863   | 30.03175    |
| 10000 | -19.423    | 32.84324    |
| 20000 | -20.7226   | 29.34737    |
| 30000 | -18.08     | 36.53333    |

### Over Temperature Even to Turn the Fan Fully On

To prevent the  $\mu$ P out of control, G7931/2 provide a function as a temperature watchdog (Set EN\_OT\_FAN high). When the temperature sensors reading exceed the trip point, G7931/2 will fully turn on the corresponding fan.

### SMBus Digital Interface

A standard SMBus 2-wire serial interface is used to read data or control the chip. The G7931/2 employs four standard SMBus protocols: Write Byte, Read Byte, Send Byte, and Receive Byte (Figure2). The SMBus address is 72h for write and 73h for read for G7932.

For G7931, the slave address can be set by add0 pin connection, as in Table 10.

**Table 10. Slave Address Selection (G7931)**

| ADD0 | ADDRESS |
|------|---------|
| GND  | 0111001 |
| Hi-Z | 1001001 |
| VDD  | 0110001 |

The G7931/2 supports SMBus clock timeout function. When SMBCLK are held low for more than 30ms (typical) during an SMBus communication the G7931/2 will reinitiate its bus interface and be ready for a new transmission.

### Alert Function and Status Registers

Except for the BUSY bit, any changing of bits of status registers which indicate alarm, ALERT pin outputs low, ALERT pin outputs low. The ALERT interrupt signal is latched and can only be cleared by reading the Alert Response address (Table 11). ALERT function can be disable by setting MASK bit in configuration registers. The ALERT pin is open-drain output. Connect a 10k $\Omega$  resister from ALERT pin to V<sub>CC</sub>.

**Table 11. Read Format for Alert Response Address (0001 100)**

| BIT    | NAME |
|--------|------|
| 7(MSB) | ADD7 |
| 6      | ADD6 |
| 5      | ADD5 |
| 4      | ADD4 |
| 3      | ADD3 |
| 2      | ADD2 |
| 1      | ADD1 |
| 0(LSB) | 1    |

**Write Byte Format**

| S | ADDRESS | WR | ACK | COMMAND | ACK | DATA   | ACK | P |
|---|---------|----|-----|---------|-----|--------|-----|---|
|   | 7 bits  |    |     | 8 bits  |     | 8 bits |     | 1 |

**Slave Address:** equivalent to chip- select line of a 3-wire interface

**Command Byte:** selects which register you are writing to

**Data byte:** data goes into the register set by the command byte (to set thresholds, configuration masks, and sampling rate)

**Read Byte Format**

| S | ADDRESS | WR | ACK | COMMAND | ACK | S | ADDRESS | RD | ACK | DATA   | /// | P |
|---|---------|----|-----|---------|-----|---|---------|----|-----|--------|-----|---|
|   | 7 bits  |    |     | 8bits   |     |   | 7bits   |    |     | 8 bits |     |   |

**Slave Address:** equivalent to chip- select line

**Command Byte:** selects which register you are reading from

**Slave Address:** repeated due to change in data-flow direction

**Data byte:** reads from the register set by the command byte

**Send Byte Format**

| S | ADDRESS | WR | ACK | COMMAND | ACK | P |
|---|---------|----|-----|---------|-----|---|
|   | 7 bits  |    |     | 8 bits  |     |   |

**Command Byte:** sends command with no data , usually used for one-shot command

**Receive Byte Format**

| S | ADDRESS | RD | ACK | DATA   | /// | P |
|---|---------|----|-----|--------|-----|---|
|   | 7 bits  |    |     | 8 bits |     |   |

**Data Byte:** reads data from the register commanded by the last Read Byte or Write Byte transmission; also used for SMBus Alert Response return address

S = Start condition   Shaded = Slave transmission   P = Stop condition   /// = Not acknowledged

**Figure 2. SMBus Protocols**

The status registers show the busy state of thermal sensors, fan abnormal conditions, and diode fault events (Table 12,13). The status byte is cleared by any successful read of status, unless the fault conditions persist.

**Table 12. Status0-Byte Bit Assignments**

| BIT     | NAME      | FUNCTION                                                           |
|---------|-----------|--------------------------------------------------------------------|
| 7 (MSB) | BUSY      | A high indicates that the ADC is busy converting.                  |
| 6       | DX2_OPEN* | A high indicates a remote-diode 2 continuity (open-circuit) fault. |
| 5       | DX1_OPEN* | A high indicates a remote-diode 1 continuity (open-circuit) fault. |
| 4       | DX2_OT#*  | A low indicates remote diode 2 over-temperature.                   |
| 3       | DX1_OT#*  | A low indicates remote diode 1 over-temperature.                   |
| 2       | RFU       | Reserved for future use.                                           |
| 1       | RFU       | Reserved for future use.                                           |
| 0 (LSB) | RFU       | Reserved for future use.                                           |

\*These flags stay high until cleared by POR, or until the status byte register is read.

**Table 13. Status1-Byte Bit Assignments**

| BIT     | NAME       | POR STATE | FUNCTION                                           |
|---------|------------|-----------|----------------------------------------------------|
| 7 (MSB) | FAN4_FAIL* | 0         | A high indicates fan4 stops.                       |
| 6       | FAN4_OOC#* | 1         | A low indicates fan4 out-of-control at close loop. |
| 5       | FAN3_FAIL* | 0         | A high indicates fan3 stops.                       |
| 4       | FAN3_OOC#* | 1         | A low indicates fan3 out-of-control at close loop. |
| 3       | FAN2_FAIL* | 0         | A high indicates fan2 stops.                       |
| 2       | FAN2_OOC#* | 1         | A low indicates fan2 out-of-control at close loop. |
| 1       | FAN1_FAIL* | 0         | A high indicates fan1 stops.                       |
| 0 (LSB) | FAN1_OOC#* | 1         | A low indicates fan1 out-of-control at close loop. |

\*These flags stay high or low until cleared by POR, or until the status byte register is read.

### Configuration Registers

Configuration registers control the ALERT mask, thermal sensors operating mode and conversion rate, over-temperature to control FAN fully on.(Table 14).

**Table 14. Configuration-Byte Bit Assignments**

| BIT | NAME        | POR STATE | FUNCTION                                                                                                                                                          |
|-----|-------------|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7   | MASK        | 0         | Masks all $\overline{\text{ALERT}}$ interrupts when high.                                                                                                         |
| 6   | RUN#/STOP   | 0         | Standby mode control bit. If high, the device immediately stops converting and enters standby mode. If low, the device converts in either one-shot or timer mode. |
| 5,4 | C-Rate      | 01        | Conversion rate control bits.                                                                                                                                     |
| 3   | EN_OT_FAN   | 0         | Enable remote OT event to control fan                                                                                                                             |
| 2   | USE_INI_CLK | 0         | 1, use internal 32768Hz clock; 0, no use it                                                                                                                       |
| 1   | RFU         | 0         | This bit should be kept to 0.                                                                                                                                     |
| 0   | RFU         | 0         | This bit should be kept to 0.                                                                                                                                     |

## Application Information

### Thermal Sensor Noise Filtering and PC Board Layout

Careful PC board layout and proper external noise filtering are required for high-frequency remote measurements in electrically noisy environments.

High-frequency EMI is best filtering at DXP and SGND with an external 2200pF capacitor. This value can be increased to about 3300pF(max), including cable capacitance. Higher capacitance than 3300pF introduces errors due to the rise time of the switched current source.

Place the G7931/2 as close as practical to the remote diode and route the DXP and SGND traces in parallel and in close proximity to each other, away from any high-voltage traces such as +12V power. For remote diodes distances longer than 8 inches,

or in particularly noisy environments, a twist pair is recommended. Nearly all noise sources tested cause the measurements higher than the actual temperature, typically +1°C to 10°C, depending on the frequency and amplitude. Leakage currents from PC board contamination must also be dealt with carefully, since a 10MΩ leakage path from DXP to ground causes about +1°C error.

VCC and GND are noisy power for fan and digital part, while VCC and SGND are clear ground for thermal sensors. Separates the two groups of power rails near the chip, and connects them as near the source as possible. Place a 100Ω resistor and 0.1μF capacitor as the low pass filter for V<sub>CC</sub>.

**Table 15. SMBus Command Byte**

| REGISTERS  | COMMAND | POR      | FUNCTION                                                                                                                                                                                                                                                                                                                 | USED BITS R/W |
|------------|---------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| TDXP2      | 00h     | 00000000 | Read DXP2 high byte                                                                                                                                                                                                                                                                                                      | [7:0]R        |
| TDXP1      | 01h     | 00000000 | Read DXP1 high byte                                                                                                                                                                                                                                                                                                      | [7:0]R        |
| STATUS0    | 02h     | X0011000 | Read status registers.<br>bit 7: BUSY, ADC is busy.<br>bit 6: OPEN2, diode 2 open.<br>bit 5: OPEN1, diode 1 open.<br>bit 4: DX2_OT#<br>bit 3: DX1_OT#.<br>bit 2~0: RFU                                                                                                                                                   | [7:0]R        |
| STATUS1    | 03h     | 01010101 | Read status registers.<br>bit 7: FAN4_FAIL: FAN4 fail.<br>bit 6: FAN4_OOC#: FAN4 out of control<br>bit 5: FAN3_FAIL: FAN3 fail.<br>bit 4: FAN3_OOC#: FAN3 out of control<br>bit 3: FAN2_FAIL: FAN2 fail<br>bit 2: FAN2_OOC#: FAN2 out of control<br>bit 1: FAN1_FAIL: FAN1 fail<br>bit 0: FAN1_OOC#: FAN1 out of control | [7:0]R        |
| CONFIG     | 04h     | 00011000 | Read/Write configuration registers.<br>bit 7: MASK, this bit mask ALERT_N output.<br>bit 6: RUN#/STOP, Standby mode control bit<br>bit 5: Conver-Rate1,<br>bit 4: Conver-Rate0, .<br>bit 3: EN_OT_FAN, Enable OT even to fully turn on the fan<br>bit 2: 1, use internal 32768Hz clock; 0, no use it<br>bit 1~0: RFU     | [7:2]R/W      |
| TONC       | 05h     | 00000000 | Read on-chip temperature sensor                                                                                                                                                                                                                                                                                          | [7:0]R        |
| TDXP12_EXT | 06h     | 00000000 | Read DXP1 extended byte<br>bit 7, 6, 5<br>Read DXP2 extended byte<br>bit 4,3, 2<br>000:0°C<br>001:0.125°C<br>010:0.25°C<br>011:0.375°C<br>100:0.5°C<br>101:0.625°C<br>110:0.75°C<br>111:0.875°C                                                                                                                          | [7:2]R        |
| TDXP1OS1   | 07h     | 00000000 | Set DXP1 default offset, 2's complement from -4°C~3.5°C, 0.5°C a step.                                                                                                                                                                                                                                                   | [3:0]R/W      |
| TDXP2OS2   | 08h     | 00000000 | Set DXP2 default offset, 2's complement from -4°C~3.5°C, 0.5°C a step.                                                                                                                                                                                                                                                   | [3:0]R/W      |
| TCRIT1     | 09h     | 01101100 | Set DXP1 over-temperature threshold                                                                                                                                                                                                                                                                                      | [7:0]R/W      |
| TCRIT2     | 0Ah     | 01011000 | Set DXP2 over-temperature threshold                                                                                                                                                                                                                                                                                      | [7:0]R/W      |
| RESET      | 0Eh     | N/A      | Making a "write" on 0Eh with any value resets all registers.<br>(*Note)                                                                                                                                                                                                                                                  | W             |
| ONESHOT    | 0Fh     | N/A      | One-shot command                                                                                                                                                                                                                                                                                                         | W             |

\* Note: The final testing uses 100k SMBus clock, 40 cycles of reading protocol to check registers value. It takes 400μs.

**Table 15. SMBus Command Byte (continued)**

| REGISTORS    | COMMAND | POR      | FUNCTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | USED BITS R/W |
|--------------|---------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| FAN1_CMD1    | 10h     | 00010000 | Read/Write FAN1 Configuration registers.<br>bit 7: DET_FAN_FAIL .<br>bit 6: DET_FAN_OOC<br>bit 5: FAN_FG_TYPE<br>bit 4: FAN_MODE 1:close-loop 0:open-loop.<br>ID of clock which to count FG.<br>bit 3: FG_CLK_ID1,<br>bit 2: FG_CLK_ID0,<br>[FG_CLK_ID1, FG_CLK_ID0]<br>00: Divide fan clock by 1<br>01: Divide fan clock by 2<br>10: Divide fan clock by 4<br>11: Divide fan clock by 1<br>FG pulses count per revolution<br>bit 1: FG_PLS_ID1,,<br>bit 0: FG_PLS_ID0,<br>[FG_PLS_ID1, FG_PLS_ID0]<br>00:2 Pulses count per revolution.<br>01:4 Pulses count per revolution.<br>10:8 Pulses count per revolution.<br>11:2 Pulses count per revolution. | [7:0]R/W      |
| FAN1_SET_CNT | 11h     | 11111111 | Set fan1 RPM in close loop control.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | [7:0]R/W      |
| FAN1_ACT_CNT | 12h     | 11111111 | Read fan1 RPM.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | [7:0]R        |
| FAN1_SET_DAC | 13h     | 00000000 | Set fan1 output voltage in open loop control.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | [7:0]R/W      |
| FAN1_CMD2    | 14h     | 00000001 | Read/Write FAN1 Configuration registers.<br>FG Gear Mode<br>bit 3: FG_Gear_Mode1,<br>bit 2: FG_Gear_Mode0,<br>[FG_Gear_Mode1, FG_Gear_Mode0]<br>00: Divide fan FG by 1<br>01: Divide fan FG by 2<br>10: Divide fan FG by 4<br>11: Divide fan FG by 1<br>FAN Start Up Voltage Setting (DA output voltage code)<br>bit 1: FAN_StartV1,,<br>bit 0: FAN_StartV0,<br>[FAN_StartV1, FAN_StartV0]<br>00:0 (1.0V)<br>01:32 (1.5V)<br>10:64 (2.0V)<br>11:96 (2.5V)                                                                                                                                                                                               | [3:0]R/W      |
| FAN2_CMD1    | 20h     | 00010000 | Read/Write FAN2 Configuration registers.<br>bit 7: DET_FAN_FAIL .<br>bit 6: DET_FAN_OOC<br>bit 5: FAN_FG_TYPE<br>bit 4: FAN_MODE 1:close-loop 0:open-loop..<br>ID of clock which to count FG.<br>bit 3: FG_CLK_ID1,<br>bit 2: FG_CLK_ID0,<br>[FG_CLK_ID1, FG_CLK_ID0]<br>00: Divide fan clock by 1<br>01: Divide fan clock by 2<br>10: Divide fan clock by 4<br>11: Divide fan clock by 1<br>FG pulses count per revolution<br>bit 1: FG_PLS_ID1,,<br>bit 0: FG_PLS_ID0,<br>[FG_PLS_ID1, FG_PLS_ID0]<br>00:2 Pulses count per revolution<br>01:4 Pulses count per revolution<br>10:8 Pulses count per revolution<br>11:2 Pulses count per revolution    | [7:0]R/W      |

**Table 15. SMBus Command Byte (continued)**

| REGISTORS    | COMMAND | POR      | FUNCTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | USED BITS R/W |
|--------------|---------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| FAN2_SET_CNT | 21h     | 11111111 | Set fan2 RPM in close loop control.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | [7:0]R/W      |
| FAN2_ACT_CNT | 22h     | 11111111 | Read fan2 RPM.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | [7:0]R        |
| FAN2_SET_DAC | 23h     | 00000000 | Set fan2 output voltage in open loop control.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | [7:0]R/W      |
| FAN2_CMD2    | 24h     | 00000001 | Read/Write FAN2 Configuration registers.<br>FG Gear Mode<br>bit 3: FG_Gear_Mode1,<br>bit 2: FG_Gear_Mode0,<br>[FG_Gear_Mode1, FG_Gear_Mode0]<br>00: Divide fan FG by 1<br>01: Divide fan FG by 2<br>10: Divide fan FG by 4<br>11: Divide fan FG by 1<br>FAN Start Up Voltage Setting (DA output voltage code)<br>bit 1: FAN_StartV1,,<br>bit 0: FAN_StartV0,<br>[FAN_StartV1, FAN_StartV0]<br>00:0 (1.0V)<br>01:32 (1.5V)<br>10:64 (2.0V)<br>11:96 (2.5V)                                                                                                                                                                                            | [3:0]R/W      |
| FAN3_CMD1    | 30h     | 00010000 | Read/Write FAN3 Configuration registers.<br>bit 7: DET_FAN_FAIL .<br>bit 6: DET_FAN_OOC<br>bit 5: FAN_FG_TYPE<br>bit 4: FAN_MODE 1:close-loop 0:open-loop..<br>ID of clock which to count FG.<br>bit 3: FG_CLK_ID1,<br>bit 2: FG_CLK_ID0,<br>[FG_CLK_ID1, FG_CLK_ID0]<br>00: Divide fan clock by 1<br>01: Divide fan clock by 2<br>10: Divide fan clock by 4<br>11: Divide fan clock by 1<br>FG pulses count per revolution<br>bit 1: FG_PLS_ID1,,<br>bit 0: FG_PLS_ID0,<br>[FG_PLS_ID1, FG_PLS_ID0]<br>00:2 Pulses count per revolution<br>01:4 Pulses count per revolution<br>10:8 Pulses count per revolution<br>11:2 Pulses count per revolution | [7:0]R/W      |
| FAN3_SET_CNT | 31h     | 11111111 | Set fan3 RPM in close loop control.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | [7:0]R/W      |
| FAN3_ACT_CNT | 32h     | 11111111 | Read fan3 RPM.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | [7:0]R        |
| FAN3_SET_DAC | 33h     | 00000000 | Set fan3 output voltage in open loop control.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | [7:0]R/W      |

Table 15. SMBus Command Byte (continued)

| REGISTORS    | COMMAND | POR      | FUNCTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | USED BITS R/W |
|--------------|---------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| FAN3_CMD2    | 34h     | 00000001 | Read/Write FAN3 Configuration registers.<br>FG Gear Mode<br>bit 3: FG_Gear_Mode1,<br>bit 2: FG_Gear_Mode0,<br>[FG_Gear_Mode1, FG_Gear_Mode0]<br>00: Divide fan FG by 1<br>01: Divide fan FG by 2<br>10: Divide fan FG by 4<br>11: Divide fan FG by 1<br>FAN Start Up Voltage Setting (DA output voltage code)<br>bit 1: FAN_StartV1,,<br>bit 0: FAN_StartV0,<br>[FAN_StartV1, FAN_StartV0]<br>00:0 (1.0V)<br>01:32 (1.5V)<br>10:64 (2.0V)<br>11:96 (2.5V)                                                                                                                                                                                            | [3:0]R/W      |
| FAN4_CMD1    | 40h     | 00010000 | Read/Write FAN4 Configuration registers.<br>bit 7: DET_FAN_FAIL .<br>bit 6: DET_FAN_OOC<br>bit 5: FAN_FG_TYPE<br>bit 4: FAN_MODE 1:close-loop 0:open-loop..<br>ID of clock which to count FG.<br>bit 3: FG_CLK_ID1,<br>bit 2: FG_CLK_ID0,<br>[FG_CLK_ID1, FG_CLK_ID0]<br>00: Divide fan clock by 1<br>01: Divide fan clock by 2<br>10: Divide fan clock by 4<br>11: Divide fan clock by 1<br>FG pulses count per revolution<br>bit 1: FG_PLS_ID1,,<br>bit 0: FG_PLS_ID0,<br>[FG_PLS_ID1, FG_PLS_ID0]<br>00:2 Pulses count per revolution<br>01:4 Pulses count per revolution<br>10:8 Pulses count per revolution<br>11:2 Pulses count per revolution | [7:0]R/W      |
| FAN4_SET_CNT | 41h     | 11111111 | Set fan4 RPM in close loop control.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | [7:0]R/W      |
| FAN4_ACT_CNT | 42h     | 11111111 | Read fan4 RPM.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | [7:0]R        |
| FAN4_SET_DAC | 43h     | 00000000 | Set fan4 output voltage in open loop control.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | [7:0]R/W      |
| FAN4_CMD2    | 44h     | 00000001 | Read/Write FAN4 Configuration registers.<br>FG Gear Mode<br>bit 3: FG_Gear_Mode1,<br>bit 2: FG_Gear_Mode0,<br>[FG_Gear_Mode1, FG_Gear_Mode0]<br>00: Divide fan FG by 1<br>01: Divide fan FG by 2<br>10: Divide fan FG by 4<br>11: Divide fan FG by 1<br>FAN Start Up Voltage Setting (DA output voltage code)<br>bit 1: FAN_StartV1,,<br>bit 0: FAN_StartV0,<br>[FAN_StartV1, FAN_StartV0]<br>00:0 (1.0V)<br>01:32 (1.5V)<br>10:64 (2.0V)<br>11:96 (2.5V)                                                                                                                                                                                            | [3:0]R/W      |



## Remote Diode Selection

Temperature accuracy depends on having a good-quality, diode-connected small-signal transistor. The G7931/2 can also directly measure the die temperature of CPUs and other integrated circuits having on-board temperature-sensing diodes.

The transistor must be a small-signal type with a relatively high forward voltage; otherwise, the A/D input voltage range can be violated. The forward voltage must be greater than 0.25V at 10 $\mu$ A; check to ensure this is true at the highest expected temperature. The forward voltage must be less than 0.95V at 300 $\mu$ A; check to ensure this is true at the lowest expected temperature. Large power transistors don't work at all. Tight specifications for forward-current gain (+50 to +150, for example) indicate that the manufacturer has good process controls and that the devices have consistent  $V_{be}$  characteristics.

Table 16 Remote-Sensor Transistor Manufacture

Table 16. Remote-Sensor Transistor Manufacturers

| MANUFACTURER                 | MODEL NUMBER |
|------------------------------|--------------|
| Philips                      | PMBS3904     |
| Motorola(USA)                | MMBT3904     |
| National Semiconductor (USA) | MMBT3904     |

Note: Transistors must be diode-connected (base shorted to collector)

## PC Board Layout

Place the G7931/2 as close as practical to the remote diode. In a noisy environment, such as a computer motherboard, this distance can be 4 in. to 8 in. (typical) or more as long as the worst noise sources (such as CRTs, clock generators, memory buses, and ISA/PCI buses) are avoided.

Do not route the DXP- SGND lines next to the deflection coils of a CRT. Also, do not route the traces across a fast memory bus, which can easily introduce +30°C error, even with good filtering. Otherwise, most noise sources are fairly benign.

Route the DXP and SGND traces in parallel and in close proximity to each other, away from any high-voltage traces such as +12V<sub>DC</sub>. Leakage currents from PC board contamination must be dealt with contamination must be dealt with carefully, since a 10M $\Omega$ . Leakage path from DXP to ground causes about +1°C error.

Connect guard traces to GND on either side of the DXP-SGND traces (Figure 3). With guard traces in place, routing near high-voltage traces is no longer an issue.

Route through as few vias and crossunders as possible to minimize copper/solder thermocouple effects. When introducing a thermocouple, make sure that both the DXP and the SGND paths have matching thermocouples. In general, PC board-induced thermocouples are not a serious problem. A copper-solder thermocouple exhibits 3 $\mu$ V/°C, and it takes about 240 $\mu$ V of voltage error at DXP- SGND to cause a +1°C measurement error. So, most parasitic thermocouple errors are swamped out.

Use wide traces. Narrow ones are more inductive and tend to pick up radiated noise. The 10mil widths and spacing recommended on Figure 3 aren't absolutely necessary (as they offer only a minor improvement in leakage and noise), but try to use them where practical. Keep in mind that copper can't be used as an EMI shield, and only ferrous materials such as steel work will. Placing a copper ground plane between the DXP-SGND traces and traces carrying high-frequency noise signals does not help reduce EMI.

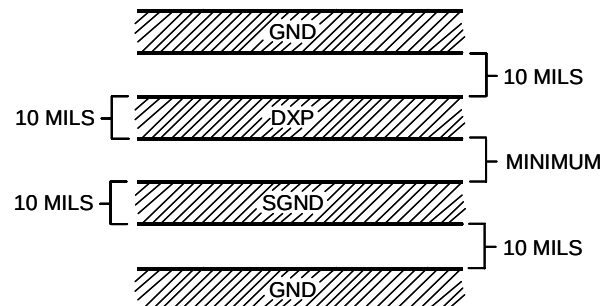


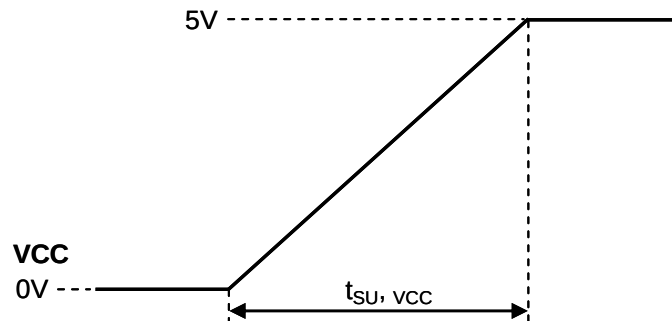
Figure 3. Recommended DXP/SGND PC Traces

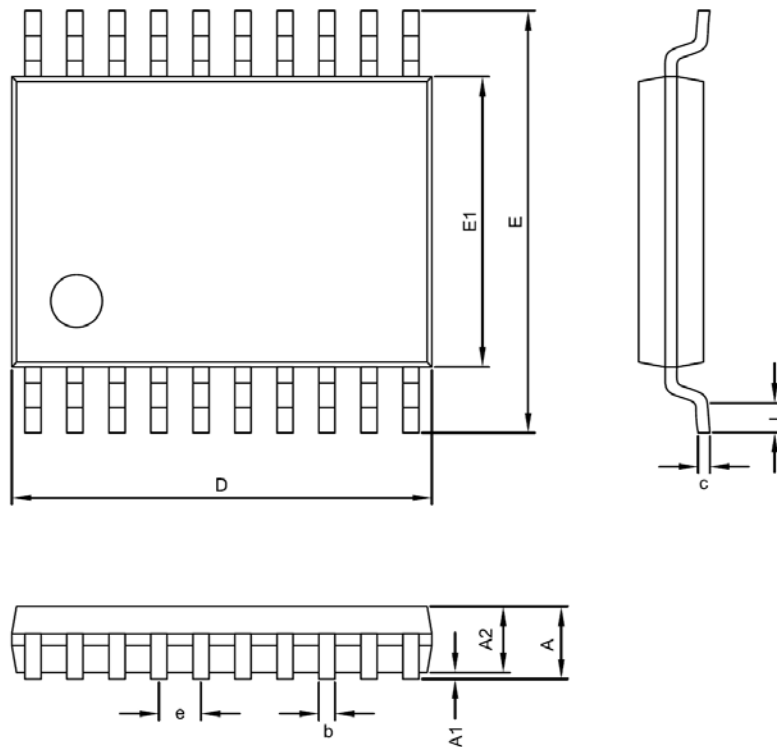
## PC Board Layout Checklist

- Place the G7931/2 close to a remote diode.
- Keep traces away from high voltages (+12V bus).
- Keep traces away from fast data buses and CRTs.
- Use recommended trace widths and spacing.
- Place a ground plane under the traces
- Use guard traces flanking DXP and SGND and connecting to GND.
- Place the noise filter and the 0.1 $\mu$ F VCC bypass capacitors close to the G7931/2.

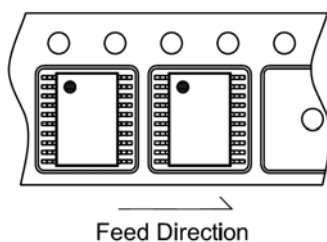
**VCC Slope for Resetting Registers**

To reset registers, the VCC start up voltage should have a gentle slope. Please refer to the below chart. The VCC ramping up from 0V to 5V takes the  $t_{SU,VCC}$  time. To reset registers properly,  $t_{SU,VCC} > 3mS$  is suggested.



**Package Information**

**TSSOP-20 Package**

| Symble | DIMENSION IN MM |      |      | DIMENSION IN INCH |       |       |
|--------|-----------------|------|------|-------------------|-------|-------|
|        | MIN.            | NOM. | MAX. | MIN.              | NOM.  | MAX.  |
| A      | ---             | ---  | 1.20 | ---               | ---   | 0.048 |
| A1     | 0.00            | ---  | 0.15 | 0.000             | ---   | 0.006 |
| A2     | 0.85            | 1.00 | 1.05 | 0.033             | 0.039 | 0.041 |
| D      | 6.40            | 6.50 | 6.60 | 0.252             | 0.256 | 0.260 |
| E      | 6.20            | 6.40 | 6.60 | 0.244             | 0.252 | 0.260 |
| E1     | 4.30            | 4.40 | 4.50 | 0.169             | 0.173 | 0.177 |
| c      | 0.09            | ---  | 0.20 | 0.004             | ---   | 0.008 |
| b      | 0.19            | 0.22 | 0.30 | 0.008             | 0.009 | 0.012 |
| e      | 0.65 BSC        |      |      | 0.026 BSC         |       |       |
| L      | 0.45            | 0.60 | 0.75 | 0.018             | 0.024 | 0.030 |

**Taping Specification**


| PACKAGE  | Q'TY/ REEL |
|----------|------------|
| TSSOP-20 | 3,000 ea   |

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