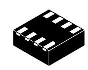
NCT1008

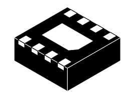
±1°C Temperature Monitor with Series Resistance Cancellation

The NCT1008 is a dual-channel digital thermometer and undertemperature/overtemperature alarm, intended for use in PCs and thermal management systems. It is register-compatible with the ADM1032 and ADT7461. A feature of the NCT1008 is series resistance cancellation, where resistance up to 1.5 k 1°C and the ambient temperature accurate to ±3°C.
e temperature measurement range defaults to 0°C to +127°C, mpatible with the ADM1032, but it can be switched to a wider easurement range of −64°C to +191°C.
The NCT1008 communicates over a 2-wire serial interface, mpatible with system management bus (SMBus/I^{2}C) standards. The default SMBus/I^{2}C address of the NCT1008 is 0x4C. An NCT1008D is available with an SMBus/I^{2}C address of 0x4D. This is useful if more than one NCT1008 is used on the same SMBus/I^{2}C.

An $\overline{\text{ALERT}}$ output signals when the on-chip or remote temperature is out of range. The $\overline{\text{THERM}}$ output is a comparator output that allows on/off control of a cooling fan. The $\overline{\text{ALERT}}$ output can be reconfigured as a second $\overline{\text{THERM}}$ output, if required.

http://onsemi.com

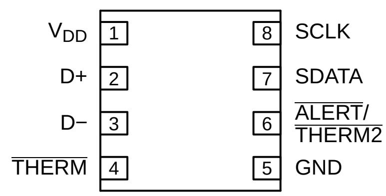




WDFN8
CASE 511AT

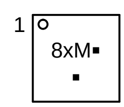
DFN8
CASE 506BJ

PIN ASSIGNMENT



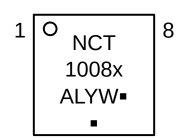
(Top View)

MARKING DIAGRAMS



WDFN8

8x = Device Code (Where x = C or D)
M = Date Code
▪ = Pb-Free Package



DFN8

x = C or D
A = Assembly Location
L = Wafer Lot
Y = Year
W = Work Week
▪ = Pb-Free Package

(Note: Microdot may be in either location)

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 18 of this data sheet.

Features

- On-chip and Remote Temperature Sensor
- 0.25°C Resolution/1°C Accuracy on Remote Channel
- 1°C Resolution/1°C Accuracy on Local Channel
- Series Resistance Cancellation Up to 1.5 kΩ
- Extended, Switchable Temperature Measurement Range 0°C to +127°C (Default) or –64°C to +191°C
- Register-compatible with ADM1032 and ADT7461
- Remote $\overline{\text{THERM}}$ Limit of 108°C
- 2-wire SMBus/I^{2}C Serial Interface with SMBus Alert Support
- Programmable Over/Undertemperature Limits
- Offset Registers for System Calibration
- Up to Two Overtemperature Fail-safe $\overline{\text{THERM}}$ Outputs
- Small 8-lead DFN
- 240 μA Operating Current, 5 μA Standby Current
- Compatible with 1.8 V Logic
- Pb-Free Packages are Available

Applications

- Smart Phones
- Desktop and Notebook Computers
- Smart Batteries
- Automotive
- Embedded Systems

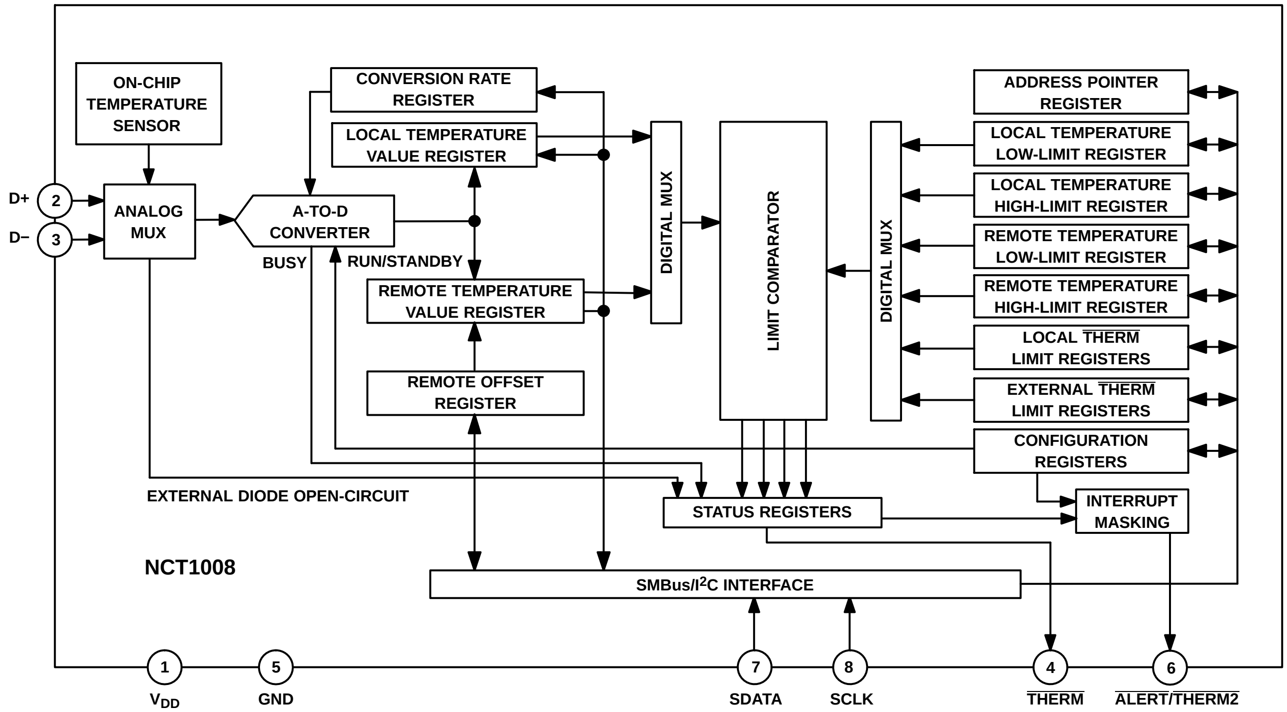


Figure 1. Functional Block Diagram

Table 1. ABSOLUTE MAXIMUM RATINGS

Parameter	Rating	Unit
Positive Supply Voltage (V_{DD}) to GND	−0.3, +3.6	V
D+	−0.3 to V_{DD} + 0.3	V
D− to GND	−0.3 to +0.6	V
SCLK, SDATA, $\overline{\text{ALERT}}$, $\overline{\text{THERM}}$	−0.3 to +3.6	V
Input Current, SDATA, $\overline{\text{THERM}}$	−1, +50	mA
Input Current, D−	±1	mA
ESD Rating, All Pins (Human Body Model)	1,500	V
Maximum Junction Temperature ($T_{J\ MAX}$)	150	°C
Storage Temperature Range	−65 to +150	°C

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect

Table 3. PIN ASSIGNMENT

Pin No.	Mnemonic	Description
1	V_{DD}	

Table 5. ELECTRICAL CHARACTERISTICS (T_A = −40°C to +125°C, V_{DD} = 2.8 V to 3.6 V, unless otherwise noted)

Parameter	Conditions	Min	Typ	Max	Unit
Power Supply					
Supply Voltage, V_{DD}		2.8	3.30	3.6	V
Average Operating Supply Current, I_{DD}	0.0625 Conversions/Sec Rate (Note 1) Standby Mode	− −	240 5.0	350 30	μA
Undervoltage Lockout Threshold	V_{DD} Input, Disables ADC, Rising Edge	−	2.55	−	V
Power-On Reset Threshold		1.0	−	2.56	V
Temperature-to-Digital Converter					
Local Sensor Accuracy 3.0 V to 3.6 V	0°C ≤ T_A ≤ +70°C 0°C ≤ T_A ≤ +85°C	− −	− −	±1.0 ±1.5	°C
Local Sensor Accuracy 2.8 V to 3.6 V	−20°C ≤ T_A ≤ +110°C	−	−	±2.5	°C
Resolution		−	1.0	−	°C
Remote Diode Sensor Accuracy 3.0 V to 3.6 V	0°C ≤ T_A ≤ +70°C, −55°C ≤ T_D (Note 2) ≤ +150°C 0°C ≤ T_A ≤ +85°C, −55°C ≤ T_D (Note 2) ≤ +150°C −4ref525.317 612 27.553 .68036 refBT8 0 0 8 67.2945 578.9481 Tm-.0007 Tc(Local Sensor Accuracy)Tj9992 -				

Theory of Operation

The NCT1008 is a local and remote temperature sensor

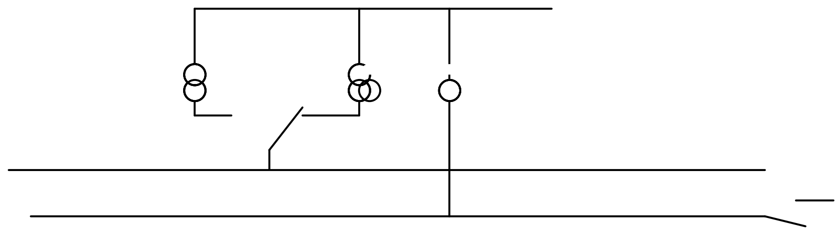


Figure 14. Input Signal Conditioning

Table 7. TEMPERATURE DATA FORMAT (TEMPERATURE HIGH BYTE)

Temperature	Binary	Offset Binary (Note 1)
–55°C	0 000 0000 (Note 2)	0 000 1001
0°C	0 000 0000	0 100 0000
+1°C	0 000 0001	0 100 0001
+10°C	0 000 1010	0 100 1010
+25°C	0 001 1001	0 101 1001
+50°C	0 011 0010	0 111 0010
+75°C	0 100 1011	1 000 1011
+100°C	0 110 0100	1 010 0100
+125°C	0 111 1101	1 011 1101
+127°C	0 111 1111	1 011 1111
+150°C	0 111 1111 (Note 3)	1 101 0110

1. Offset binary scale temperature values are offset by 64°C.
2. Binary scale temperature measurement returns 0

Conversion Rate Register

The conversion rate register is Address 0x04 at read and Address 0x0A at write. The lowest four bits of this register are used to program the conversion rate by dividing the internal oscillator clock by 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, or 1024 to give conversion times from 15.5 ms (Code 0x0A) to 16 seconds (Code 0x00). For example, a conversion rate of eight conversions per second means that beginning at 125 ms intervals, the device performs a conversion on the internal and the external temperature channels.

The conversion rate register can be written to and read back over the SMBus/I^2C. The higher four bits of this register are unused and must be set to 0. The default value of this register is 0x08, giving a rate of 16 conversions per second. Use of slower conversion times greatly reduces the device power consumption.

Table 9. CONVERSION RATE REGISTER CODES

Code	Conversion/Second	Time
0x00	0.0625	16 s0x00

set, the $\overline{\text{THERM2}}$ output goes low to indicate that the

Table 13. LIST OF REGISTERS

Read Address (Hex)	Write Address (Hex)	Name	Power-On Default
Not Applicable	Not Applicable	Address Pointer	Undefined
00	Not Applicable	Local Temperature Value	0000 0000 (0x00)
01	Not Applicable	External Temperature Value High Byte	0000 0000 (0x00)
02	Not Applicable	Status	Undefined
03	09	Configuration	0000 0000 (0x00)
04	0A	Conversion Rate	0000 1000 (0x08)
05	0B	Local Temperature High Limit	0101 0101 (0x55) (85°C)
06	0C	Local Temperature Low Limit	

3. When all data bytes have been read or written, stop conditions are established. In write mode, the master pulls the data line high during the tenth clock pulse to assert1008

When reading data from a register there are two possibilities.

- If the address pointer register value of the NCT1008 is unknown or not the desired value, it is first necessary to set it to the correct value before data can be read from the desired data register. This is done by writing to the NCT1008 as before, but only the data byte containing the register read address is sent, because data is not to be written to the register see Figure 16.
  A read operation is then performed consisting of the serial bus address, R/$\overline{\text{W}}$ bit set to 1, followed by the data byte read from the data register see Figure 17.
- If the address pointer register is known to be at the desired address, data can be read from the corresponding data register without first writing to the address pointer register and the bus transaction shown in Figure 16 can be omitted.

Notes:

- It is possible to read a data byte from a data register without first writing to the address pointer register. However, if the address pointer register is already at the correct value, it is not possible to write data to a register without writing to the address pointer register because the first data byte of a write is always written to the address pointer register.
- Some of the registers have different addresses for read and write operations. The write address of a register must be written to the address pointer if data is to be written to that register, but it may not be possible to read data from that address. The read address of a register must be written to the address pointer before data can be read from that register.

$\overline{\text{ALERT}}$ Output

This is applicable when Pin 6 is configured as an $\overline{\text{ALERT}}$ output. The $\overline{\text{ALERT}}$ output goes low whenever an out-of-limit measurement is detected, or if the remote temperature sensor is open circuit. It is an open-drain output and requires a pullup resistor to V_{DD}. Several $\overline{\text{ALERT}}$ outputs can be wire-OR'ed together, so that the common line goes low if one or more of the $\overline{\text{ALERT}}$ outputs goes low.

The $\overline{\text{ALERT}}$ output can be used as an interrupt signal to a processor, or as an $\overline{\text{SMBALERT}}$. Slave devices on the SMBus cannot normally signal to the bus master that they want to talk, but the $\overline{\text{SMBALERT}}$ function allows them to do so.

One or more $\overline{\text{ALERT}}$ outputs can be connected to a common $\overline{\text{SMBALERT}}$ line that is connected to the master. When the $\overline{\text{SMBALERT}}$ line is pulled low by one of the devices, the following procedure occurs (see Figure 18):

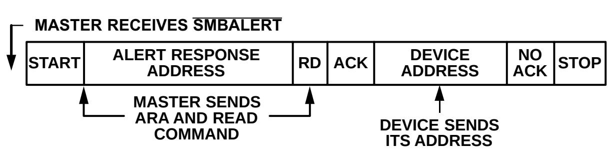


Figure 18. Use of $\overline{\text{SMBALERT}}$

1. $\overline{\text{SMBALERT}}$ is pulled low.
2. Master initiates a read operation and sends the alert response address (ARA = 0001 100). This is a general call address that must not be used as a specific device address.
3. The device whose $\overline{\text{ALERT}}$ output is low responds to the alert response address and the master reads its device address. As the device address is seven bits, an LSB of 1 is added. The address of the device is now known and it can be interrogated in the usual way.

8 -A,

(typical), signifying an open circuit between D+ and D−. The output of this comparator is checked when a conversion is initiated. Bit 2 of the status register (open flag) is set if a fault is detected. If the ALERT pin is enabled, setting this flag causes ALERT to assert low.

If the user does not wish to use an external sensor with the NCT1008, tie the D+ and D− inputs together to prevent continuous setting of the open flag.

The NCT1008 Interrupt System

The NCT1008 has two interrupt outputs, ALERT and THERM. Both have different functions and behavior. ALERT is maskable and responds to violations of software programmed temperature limits or an open-circuit fault on the external diode. THERM is intended as a fail-safe interrupt output that cannot be masked.

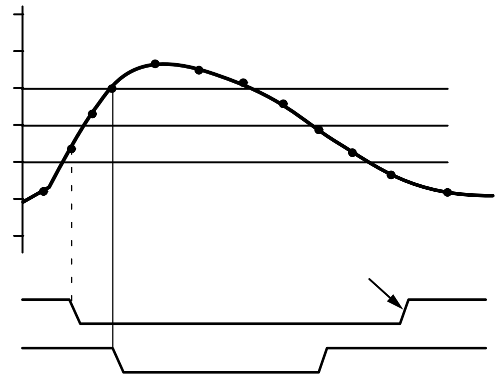
If the external or local temperature exceeds the programmed high temperature limits, or equals or exceeds the low temperature limits, the ALERT output is asserted low. An open-circuit fault on the external diode also causes ALERT to assert. ALERT is reset when serviced by a master [redacted] temperature exceeds the programmed THERM limits. THERM temperature limits should normally be equal to or greater than the high temperature limits. THERM is reset automatically when the temperature falls back within the THERM limit. A hysteresis value can be programmed; in which case, THERM resets when the temperature falls to the limit value minus the hysteresis value. This applies to both local and remote measurement channels. The power-on hysteresis default value is 10°C, but this can be reprogrammed to any value after powerup.

The hysteresis loop on the THERM outputs is useful when THERM is used, for example, as an on/off controller for a fan. The user's system can be set up so that when THERM asserts, a fan is switched on to cool the system. When THERM goes high again, the fan can be switched off. Programming a hysteresis value protects from fan jitter, where the temperature hovers around the THERM limit, and the fan is constantly switched.

Table 14. THERM HYSTERESIS

THERM Hysteresis	Binary Representation
0°C	0 000 0000
1°C	0 000 0001
10°C	0 000 1010

Figure 19 shows how the THERM and ALERT outputs operate. The ALERT output can be used as a SMBALERT to signal to the host via the SMBus that the temperature has risen. The user can use the THERM output to turn on a fan to cool the system, if the temperature continues to increase. This method ensures that there is a fail-safe mechanism to cool the system, without the need for host intervention.

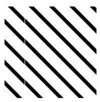


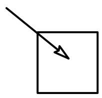
[redacted]

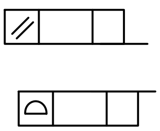
Figure 20. Operation of the $\overline{\text{THERM}}$ and $\overline{\text{THERM2}}$ Interrupts

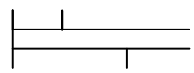
•

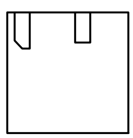
DFN8 3x3, 0.5P
CASE 506BJ
ISSUE O

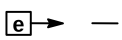











e