NCT175

Industry Standard Digital Temperature Sensor with 2-wire Interface

The NCT175 is a two-wire serially programmable temperature sensor with an over-temperature/interrupt output pin to signal out of limit conditions. This is an open-drain pin and can operate in either comparator or interrupt mode. Temperature measurements are converted into digital form using a high resolution (12 bit), sigma-delta, analog-to-digital converter (ADC). The device operates over the –55°C to +125°C temperature range.

Communication with the NCT175 is accomplished via the SMBus/I2C interface. Three address selection pins, A2, A1 and A0, can be used to connect up to 8 NCT175s to a single bus. Through this interface the NCT175s internal registers may be accessed. These registers allow the user to read the current temperature, change the configuration settings and adjust the temperature limits.

The NCT175 has a wide supply voltage range of 3.0 V to 5.5 V. The average supply current is 575 μA at 3.3 V. It also offers a shutdown mode to conserve power. The typical shutdown current is 3 μA.

The NCT175 is available in 8-lead Micro8™ and is also fully pin and register compatible with the NCT75, LM75 and TCN75.

Features

- 12-bit Temperature-to-Digital Converter
- Input Voltage Range from 3.0 V to 5.5 V
- Temperature Range from −55°C to +125°C
- SMBus/I2C Interface
- Overtemperature Indicator
- Support for SMBus/$\overline{\text{ALERT}}$
- Shutdown Mode for Low Power Consumption
- One-shot Mode
- Available in 8−pin Micro8 Package
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

Applications

- Computer Thermal Monitoring
- Thermal Protection
- Isolated Sensors
- Battery Management
- Office Electronics
- Electronic Test Equipment
- Thermostat Controls
- System Thermal Management

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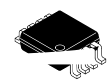
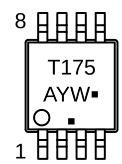


Micro8™
CASE 846A

PIN ASSIGNMENT

MARKING DIAGRAM



Micro8™

A	= Assembly Location
Y	= Year
W	= Work Week
▪	= Pb-Free Package

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 12 of this data sheet.

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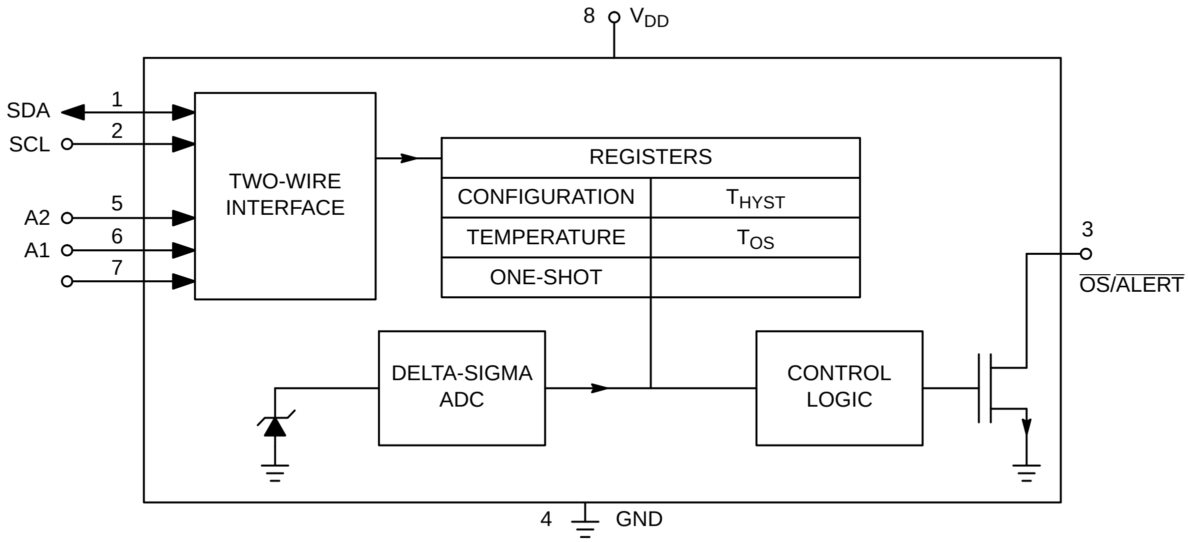


Figure 1. Simplified Block Diagram

Table 5. ELECTRICAL CHARACTERISTICS
(T_A = T_{MIN} to T_{MAX}, V_{DD}

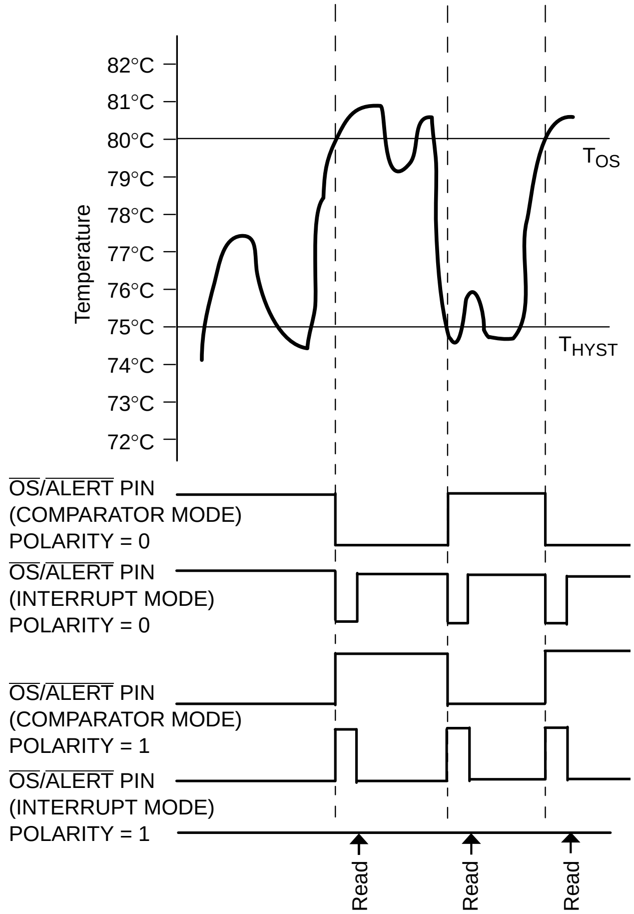


Figure 4. One-shot $\overline{OS}/\overline{ALERT}$ Pin Operation

Fault Queue

A fault is defined as when the temperature exceeds a pre-defined temperature limit. This limit can be programmed in the T_{HYST} and the T_{OS} setpoint registers. Bits 3 and 4 of the configuration register determine the number of faults necessary to trigger the $\overline{OS}/\overline{ALERT}$ pin. Up to six faults can be programmed to prevent false tripping when the NCT175 is used in a noisy temperature environment. In order for the $\overline{OS}/\overline{ALERT}$ output to be set these faults must occur consecutively.

Registers

The NCT175 contains six registers for configuring and reading the teperature: the address pointer register, 4 data registers and a one-shot register. The configuration register, the address pointer register and the one-shot register are all 8 bits wide while the temperature register, T_{HYST} and T_{OS} registers are all 16 bits wide. All registers, except for the temperature register, can be be read from and written to (the temperature register is read only). The power on state and address of each register are listed in Table 9.

Address Pointer Register

The address pointer register is used to select which register is to respond to a read or write operation. The three LSBs (P2, P1 & P0) of this write only register are used to select the appropriate register. On power up this register is loaded with a value of 0x00 and so points to the temperature register. Table 7 shows the bits of the address pointer register and Table 8 shows the pointer address selecting each of the registers available.

Table 7. ADDRESS POINTER REGISTER

	P7	P6	P5	P4	P3	P2	P1	P0
Default	0	0	0	0	0	0	0	0

Table 8. REGISTER ADDRESSES SELECTION

P2	P1	P0	Register Selected
0	0	0	Stored Temperature
0	0	1	Configuration
0	1	0	T_{HYST} Setpoint
0	1	1	T_{OS} Setpoint
1	0	0	One-shot

Table 9. NCT175 REGISTER SET

Register Address	Register Name	Power-on Default Value	
		Hex	°C
0x00 (R)	Stored Temperature Value	0x0000	0
0x01 (R/W)	Configuration	0x00	−
0x02 (R/W)	T_{HYST}	0x4B00	75
0x03 (R/W)	T_{OS}	0x5000	80
0x04 (R/W)	One-shot	0xXX	−

Temperature Register

The temperature measured by the parts internal sensor is stored in this 16-bit read only register. The data is stored in twos complement format with the MSB as the sign bit. The 8 MSBs must be read frist followed by the 8 LSBs.

Table 10. TEMPERATURE VALUE REGISTER

MSB / LSB

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	0	0	0	0	0	0	0	0	X	X	X	X

Configuration Register

This 8-bit read/write register is used to configure the NCT175 into its various modes of operation. The different modes are listed in Table 11 and explained in more detail below.

Table 11. CONFIGURATION REGISTER

Bit	Configuration	Default Value
D7	Reserved	0
D6	Reserved	0
D5	One-shot Mode	0
D4	Fault-queue	0
D3	Fault-queue	0
D2	$\overline{\text{OS}}/\overline{\text{ALERT}}$ Pin Polarity	0
D1	Cmp/Int Mode	0
D0	Shutdown Mode	0

D7: Reserved
Write 0 to this bit.

D6: Reserved
Write 0 to this bit.

D5: One-shot Mode
D5 = 0 Part is in normal mode and converting every 60 ms. (Default)
D5 = 1 Setting this bit puts the part into one-shot mode. The part is normally powered down in this mode until the one shot register is written to. Once this register is written to one conversion is performed and the part returns to its shutdown state.

D[4:3]: Fault Queue
D4 D3 These two bits determine how many overtemperature conditions occur before the $\overline{\text{OS}}/\overline{\text{Alert}}$ pin is triggered. This helps to prevent false triggering of the output.
0 0 = 1 Fault (Default)
0 1 = 2 Faults
1 0 = 4 Faults
2 1 = 6 Faults

D2: $\overline{\text{OS}}/\overline{\text{Alert}}$ pin polarity
This selects the polarity of the $\overline{\text{OS}}/\overline{\text{Alert}}$ output pin.
D2 = 0 Output is active low. (Default)
D2 = 1 Output is active high.

D1: Cmp/Int
D1 = 0 Comparator mode. (Default)
D1 = 1 Interrupt mode.

D0: Shutdown
D0 = 0 Normal mode – part is fully powered. (Default)
D0 = 1 Shutdown mode – all circuitry except for the SMBus interface is powered down. Write a 0 to this bit to power up again.

T_{HYST} Register

The T_{HYST} register stores the temperature hysteresis value

Serial Interface

Control of the NCT175 is carried out via the SMBus/I^{2}C compatible serial interface. The NCT175 is connected to this bus as a slave device, under the control of a master device.

Serial Bus Address

Control of the NCT175 is carried out via the serial bus. The NCT175 is connected to this bus as a slave device under the control of a master device. The NCT175 has a 7-bit serial address. The four MSBs are fixed and set to 1001 while the 3 LSBs can be configured by the user using pins 5, 6 and 7 (A2, A1 and A0). Each of these pins can be configured in one of two ways low or high. This gives eight different address options listed in Table 14 below. The state of these pins is continually sampled and so can be changed after power up.

Table 14. SERIAL BUS ADDRESS OPTIONS

MSBs				LSBs			Address
A6	A5	A4	A3	A2	A1	A0	Hex
1	0	0	1	0	0	0	0x48
1	0	0	1	0	0	1	0x49
1	0	0	1	0	1	0	0x4A
1	0	0	1	0	1	1	0x4B
1	0	0	1	1	0	0	0x4C
1	0	0	1	1	0	1	0x4D
1	0	0	1	1	1	0	0x4E
1	0	0	1	1	1	1	0x4F

The NCT175 also features a SMBus/I^{2}C timeout function whereby the SMBus/I^{2}C interface times out after the specified time when there is no activity on the SDA line. After this time, the NCT175 resets the SDA line back to its idle state (high impedance) and waits for the next start condition.

The serial bus protocol operates as follows:

1. The master initiates data transfer by establishing a start condition, defined as a high to low transition on the serial data line SDA, while the serial clock line SCL remains high. This indicates that an address/data stream is going to follow. All slave peripherals connected to the serial bus respond to the start condition and shift in the next eight bits, consisting of a 7-bit address (MSB first) plus a read/write (R/$\overline{W}$) bit, which determines the direction of the data transfer i.e. whether data is written to, or read from, the slave device. The peripheral with the address corresponding to the transmitted address responds by pulling the data line low during the low period before the ninth clock pulse, known as the acknowledge bit. All other devices on the bus now remain idle while the selected device waits for data to be read from or written to it. If the R/$\overline{W}$ bit is a zero then the master writes to the slave device. If the R/$\overline{W}$ bit is a one then the master reads from the slave device.
2. Data is sent over the serial bus in sequences of nine clock pulses, eight bits of data followed by an acknowledge bit from the receiver of data. Transitions on the data line must occur during the low period of the clock signal and remain stable during the high period, since a low-to-high transition when the clock is high can be interpreted as a stop signal.
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 assert a stop condition. In read mode, the master overrides the acknowledge bit by pulling the data line high during the low period before the ninth clock pulse. This is known as no acknowledge. The master takes the data line low during the low period before the tenth clock pulse, then high during the tenth clock pulse to assert a stop condition.

Any number of bytes of data can be transferred over the serial bus in one operation. However, it is not possible to mix read and write in one operation because the type of operation is determined at the beginning and cannot subsequently be changed without starting a new operation.

Writing Data

There are two types of writes used in the NCT175:

Setting up the Address Pointer Register for a Register Read

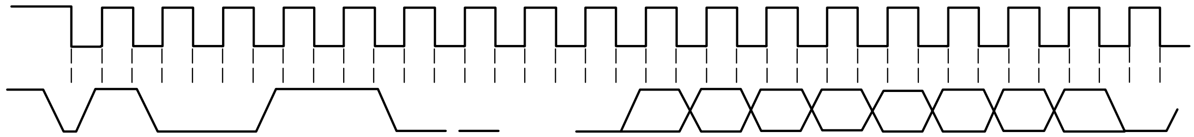
To read data from a particular register, the address pointer register must hold the address of the register being read. To configure the address pointer register a single write operation (shown in Figure 5). It consists of the device address followed by the address being written to the address pointer register. This will then be followed by a read operation.

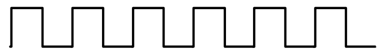
Writing Data to a Register

Due to the different size registers used by the NCT175, there are two types of write operations. One is for the 8 bit wide configuration register and the other for the 16 bit wide limit registers.

Figure 6 shows the sequence required to write to the configuration register. It consists of the device address, the data register being written to and the data being written the selected register.

The two temperature limit registers (T_{HYST} and T_{OS}) are 16 bits wide and require two data bytes to be written to these registers. This sequence is shown in Figure 7. It consists of the device address, the data register being written to and the two data byes being written to the selected register.





Reading Data

Reading data from the NCT175 is done in two different ways depending on the register being read. The configuration register is only 8 bits wide so a single byte read is used for this (shown in Figure 8). This consists of the device address followed by the data from the register.

Reading

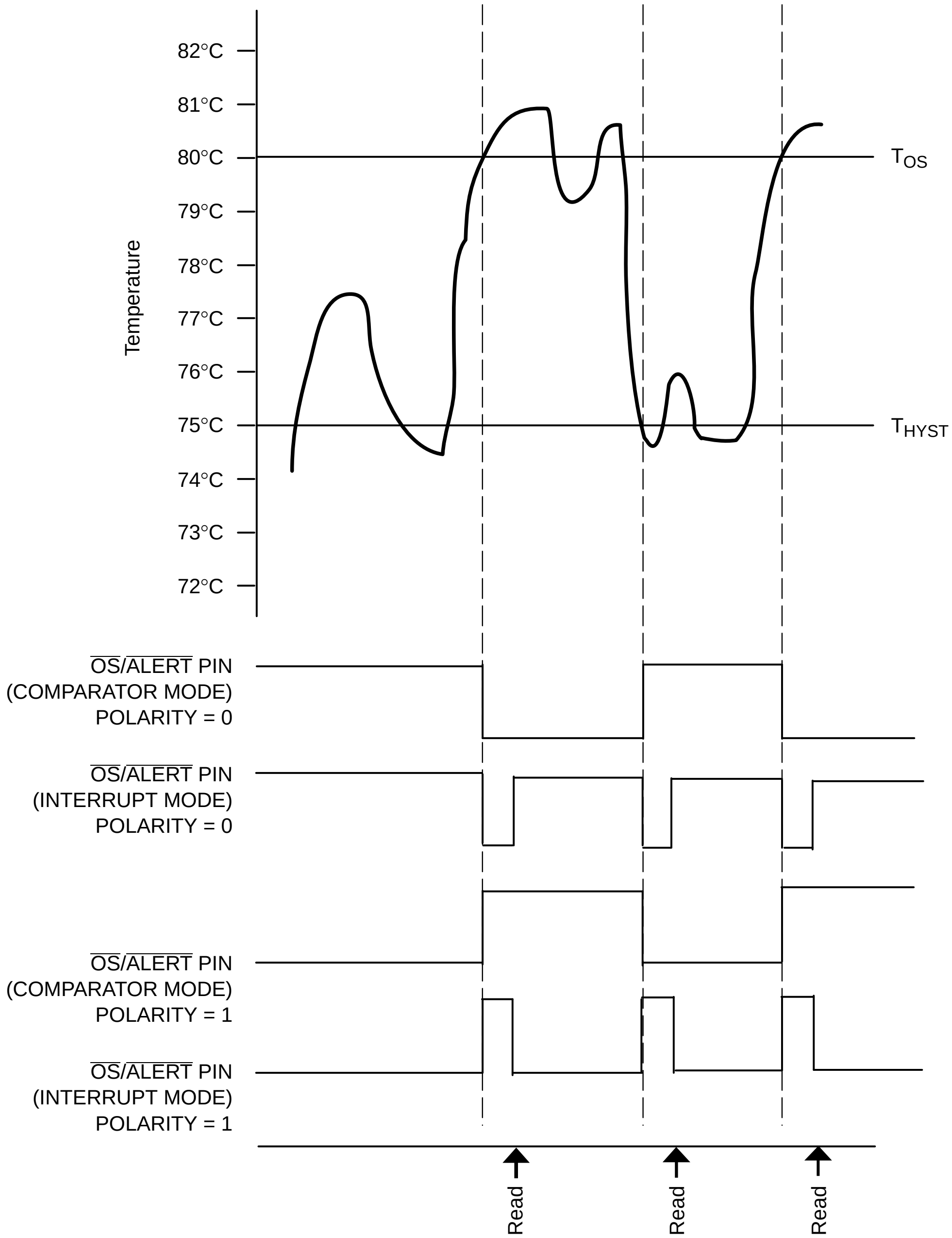


Figure 11. $\overline{OS}/\overline{ALERT}$ Output Temperature Response Diagram

Table 15. ORDERING INFORMATION

Model Number	Temperature Range	Temperature Accuracy	Package Description	Package Option†
NCT175DMR2G	−55°C to +125°C	±1°C	Micro8 (Pb−Free)	3,000 / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

PACKAGE DIMENSIONS

Micro8™
CASE 846A−02
ISSUE H